Mapping extent, volume and carbon content of global tropical wetlands

Preliminary global results

TWINCAM/SWAMP

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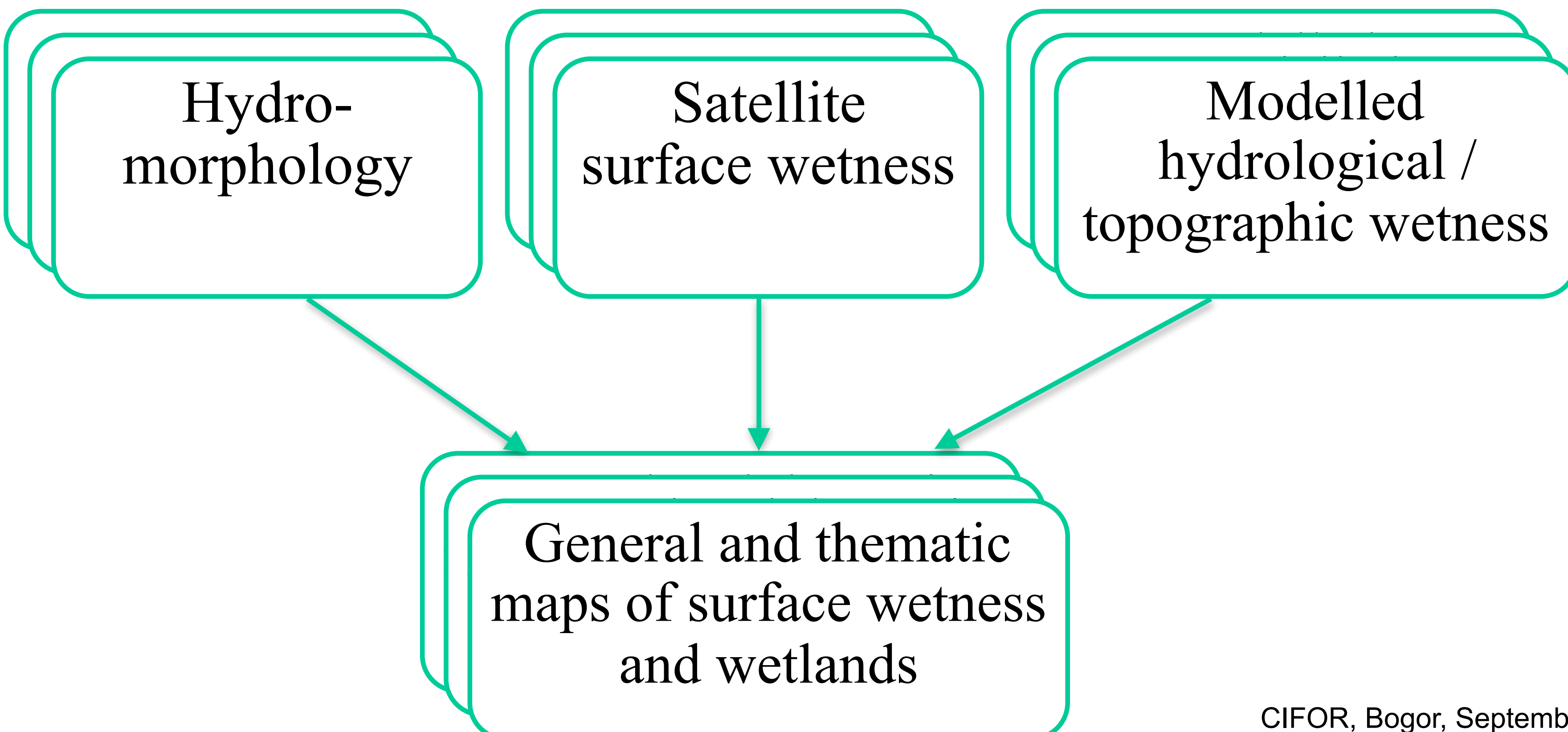
Data sources for wetland mapping

Wetlands can be mapped from a variety of data sources:

- Ground survey (older topographic maps)
- Aerial photos (modern topographic maps)
- Optical satellite images
- Thermal satellite images
- Microwave (radar) satellite images
- Elevation data (e.g. from radar or lidar satellite images)
- Gravimetric data (large water bodies with volume changes)
- Combinations of 2 or more of the above

The SWAMP mapping approach

SWAMP wetland classification is based on a hybrid expert system that combines knowledge on hydromorphology, satellite derived surface wetness and surface wetness modelled from hydrology and topography.

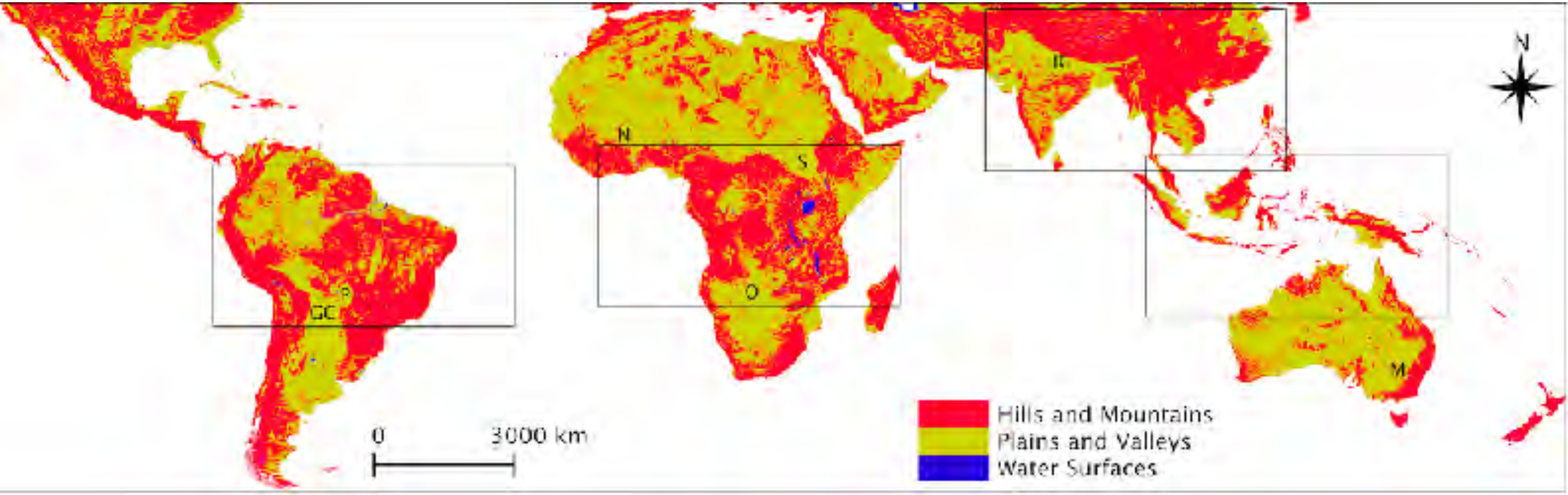


The SWAMP mapping approach

- Hydromorphological maps
  - Hydraulic terrain relief
  - Channel valleys
  - Small and Large valleys (with or without flowing channels)
  - General geomorphology
  - Plain and valley geomorphology
  - Dome shaped features
  - Valley shaped featured
  - Plains and valleys

The SWAMP mapping approach

Plains and valleys



Some of the world's major alluvial deposits harboring floodout wetlands are indicated as letter codes; GC: Gran Chaco; IG: Indo-Gangetic Plains; M: Macquarie; N: Niger Inland Delta; O: Okavango; P: Pantanal.

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- Satellite surface wetness

Global surface wetness is routinely estimated from microwave (think: radar) images at very coarse spatial resolution (25 km). In SWAMP we used more high resolution (500 m) optical images and a Transformed Wetness Index (TWI) to map global wetness att 500 m.

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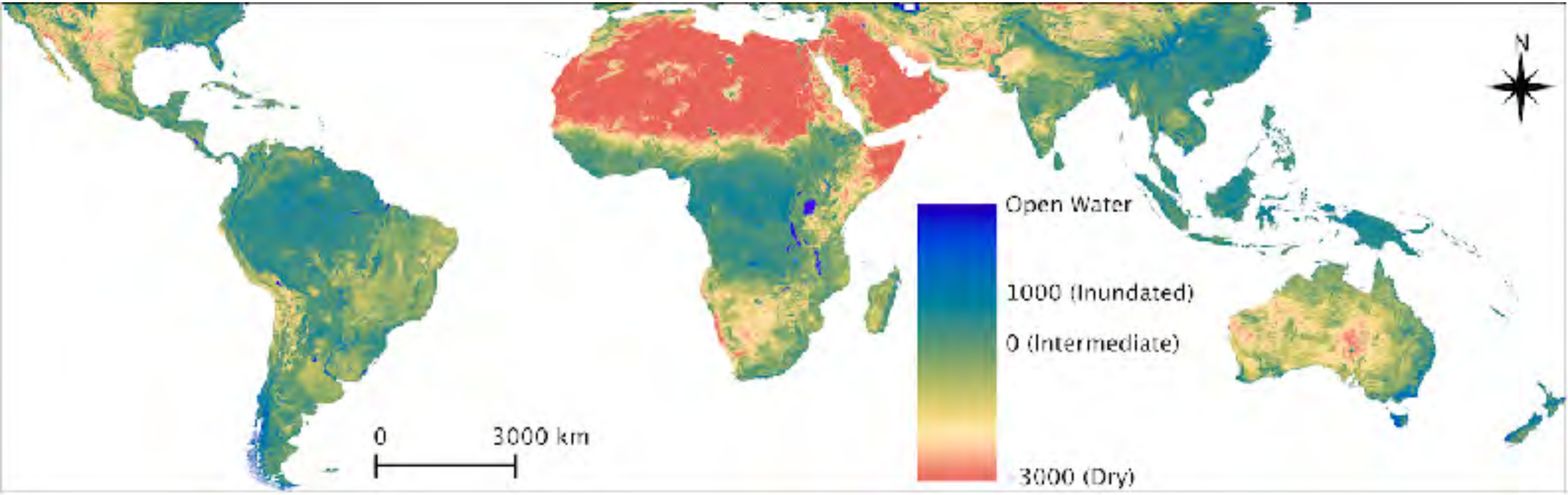
Satellite surface wetness - TWI



Average TWI for the calendar year 2011

The SWAMP mapping approach

Wetness seasonal phenomena (phenology)

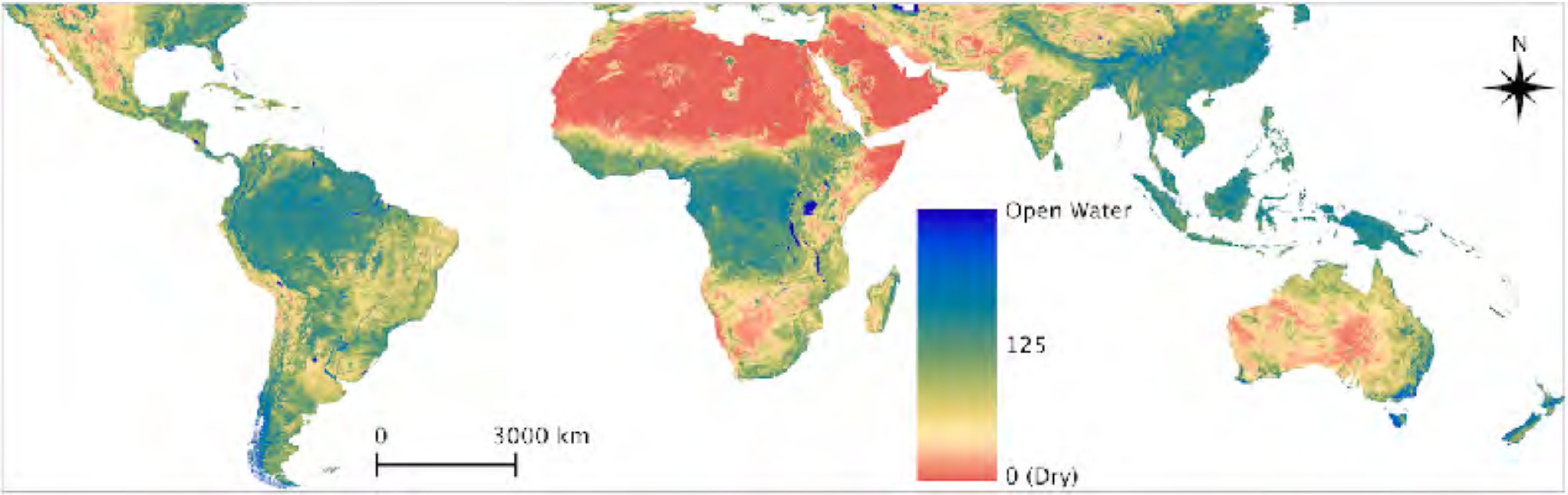
From an annual time series of TWI different phenological metrics can be estimated, for example:

- Minimum wetness
- Maximum wetness
- Average wetness
- Length of dry/wet seasons
- Length of inundation periods

Different wetlands require different wetness phenology, and indexes capturing general and thematic wetness phenology were developed.

The SWAMP mapping approach

compound Transformed Wetness Index (cTWI)



cTWI for general surface wetness 2011

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Hydrological and topographic surface wetness

The Topographic Convergence Index (TCI) measures the surface wetness derived from a water balance model and local topography. TCI has been used for mapping wetlands in temperate climate, and was adjusted for mapping tropical wetlands within SWAMP.

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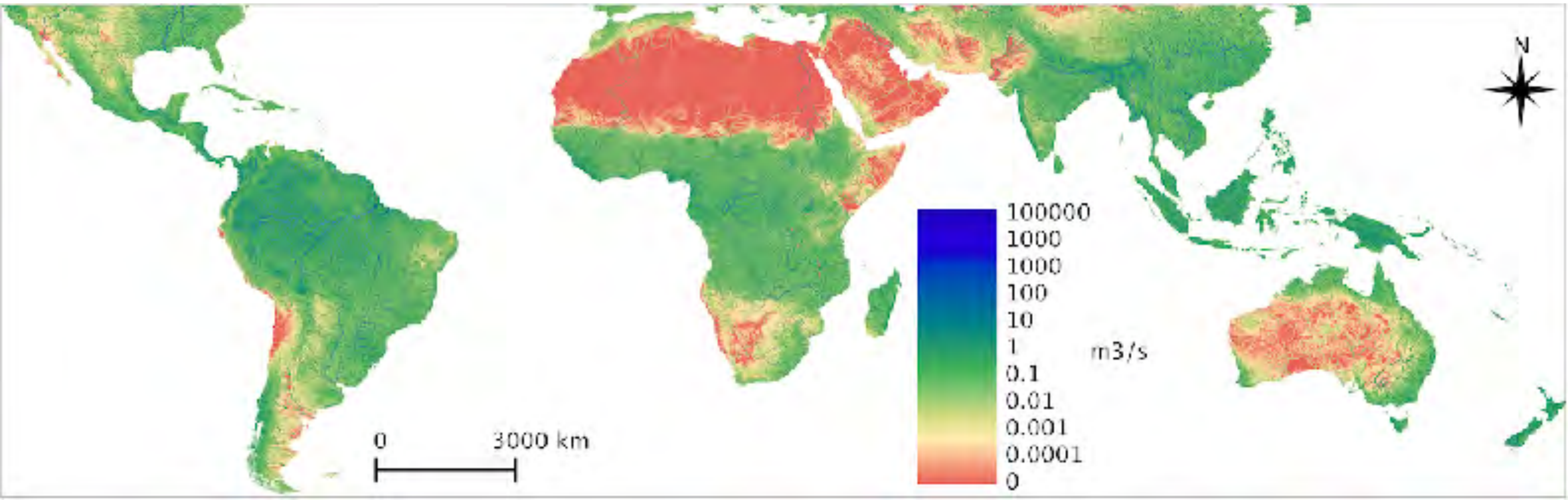
Global water balance



The Global water balance (1950-2000 average) modelled at an unprecedented spatial scale of 250 m

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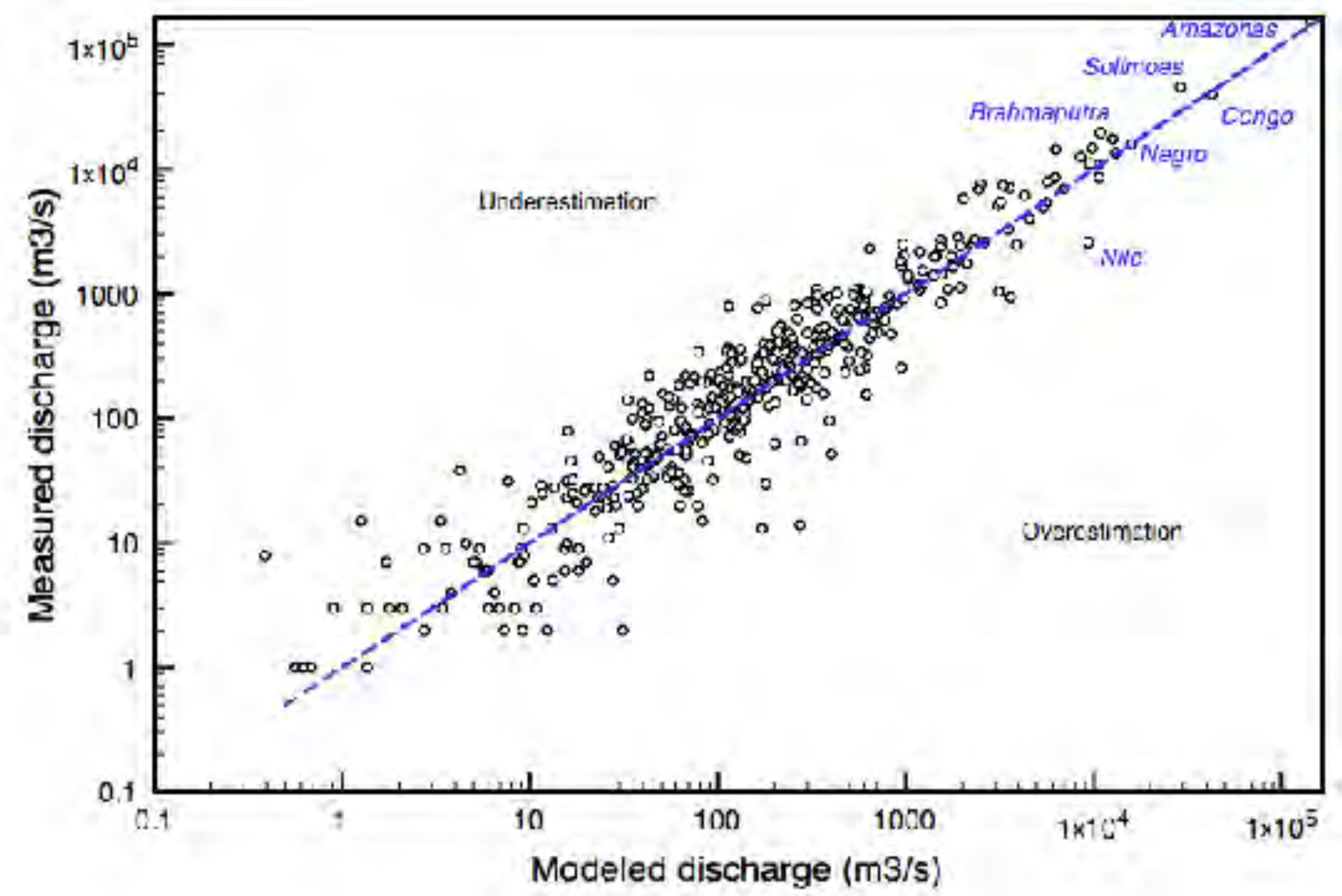
Global water balance - model validation



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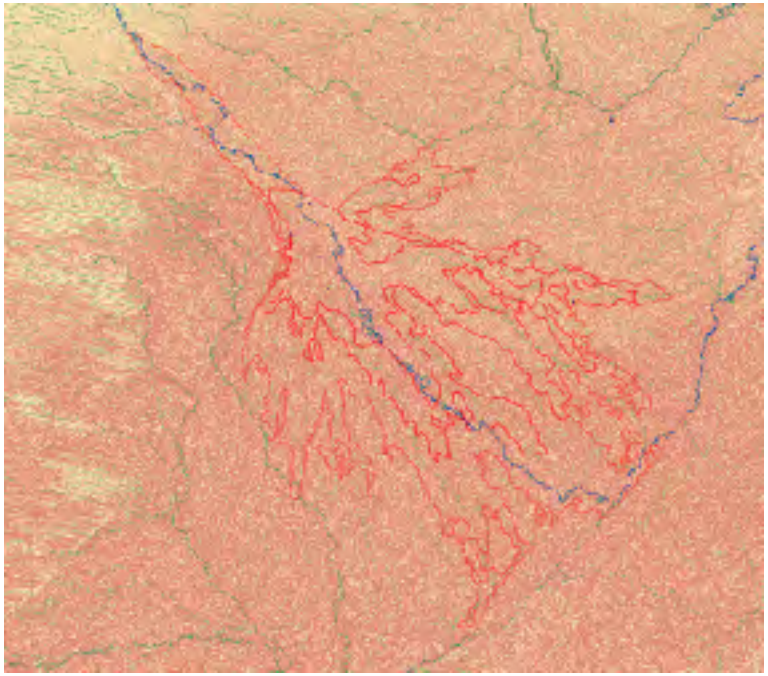
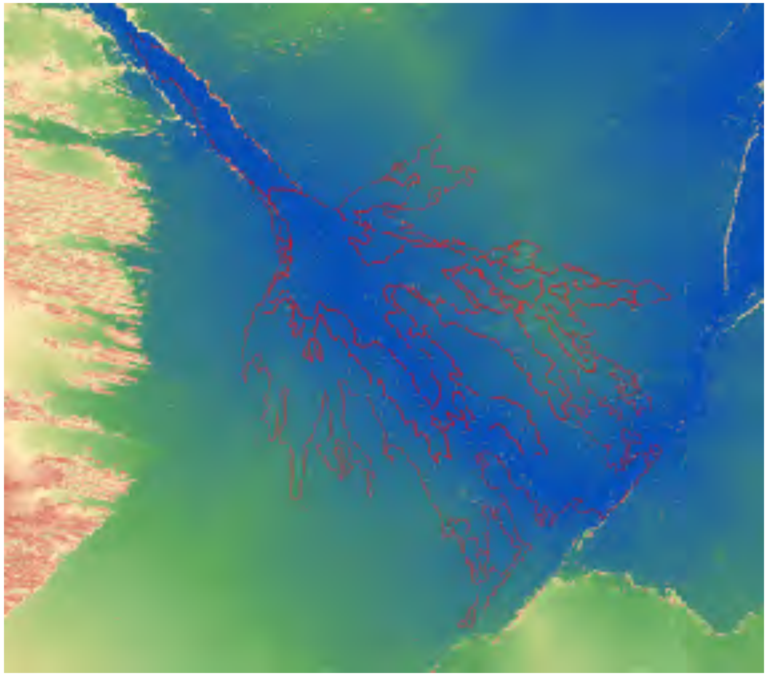
Global water balance - flooded areas





The hydrological model confines water flow to channels (left), and a flood routine allowing channeled flow to flood valleys and plains adjacent to channels was added (right). The map shows the Okavango swamps (red outline) with and without the flooding routine.

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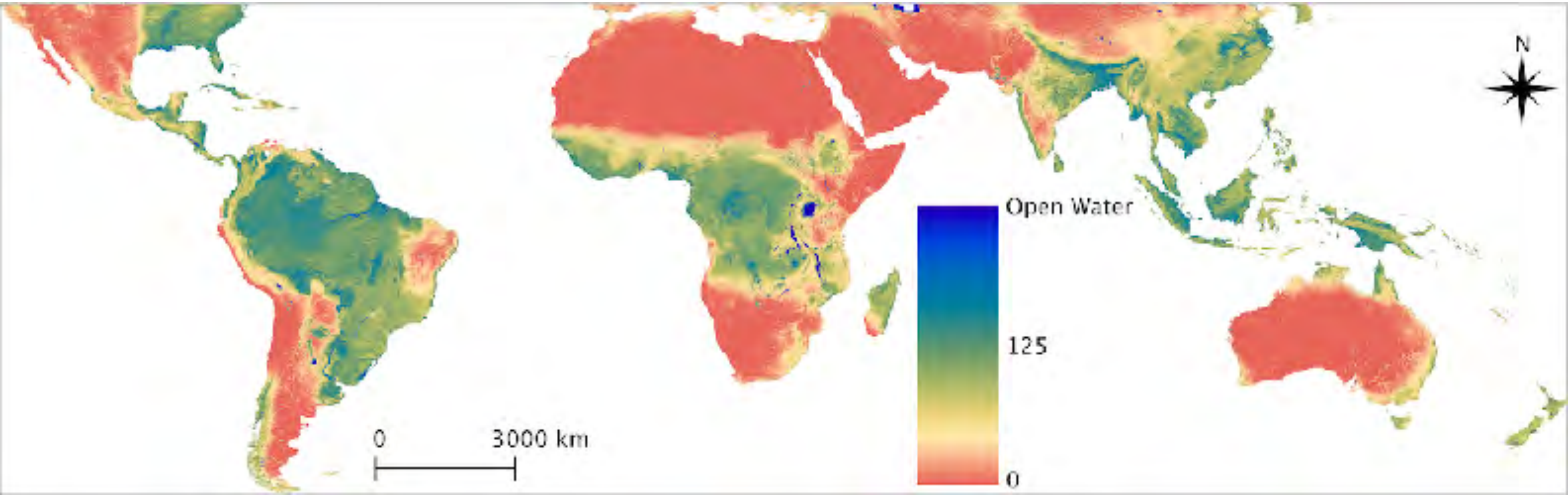
Wetland Topographic Convergence Index (WTCI)



The global water flow and flooding models in combination with local topography were used to define both general and thematic Wetland Topographic Convergence Indexes (WTCI), excluding all regions where the atmospheric water demands (evapotranspiration) exceed available water.

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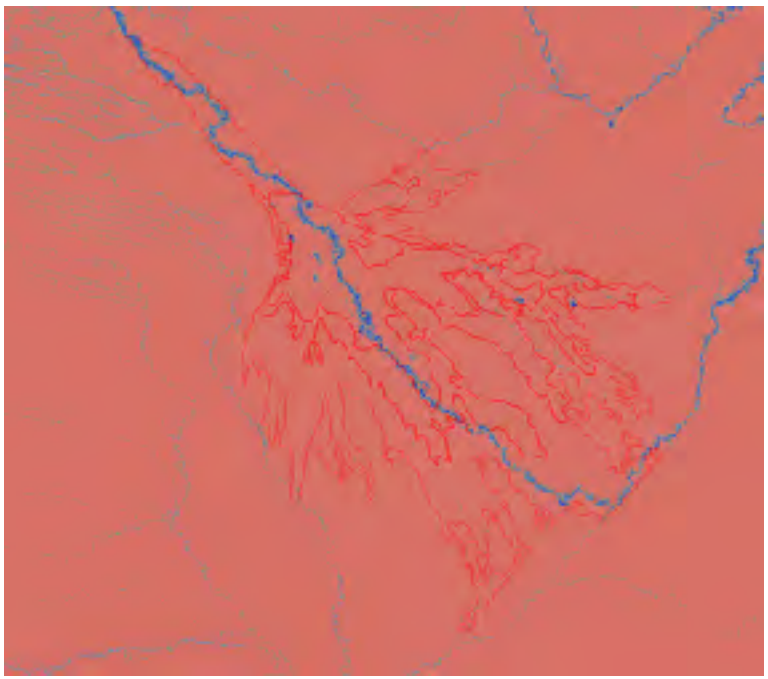
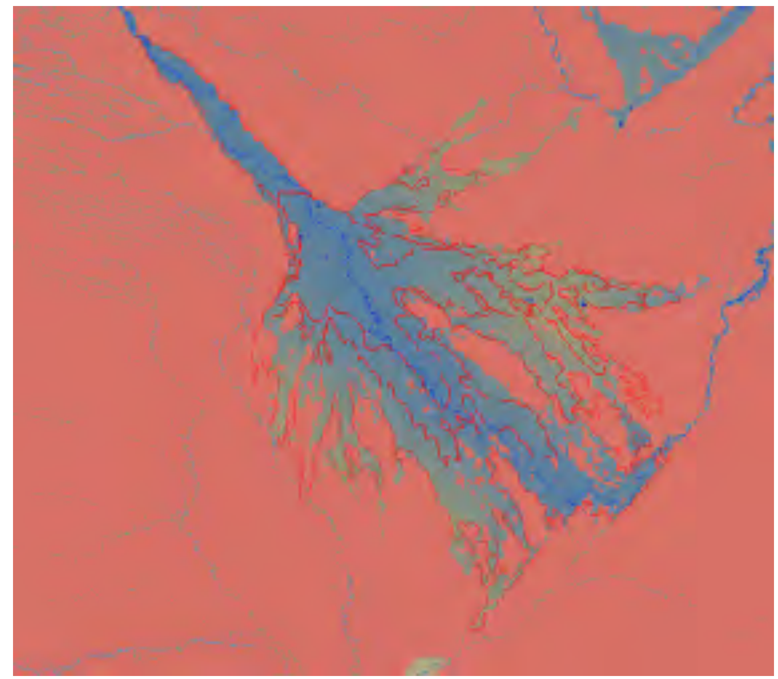
Wetland Topographic Convergence Index (WTCI)





Returning to the Okavango Swamp, WTCI excluding the flooding routine only captures the Okavango River (left). WTCI including the flooding, but excluding all regions with no recorded inundation from the phenology of the satellite derived surface wetness looks much better (right).

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Wetland and wetness hybrid expert mapping

The actual mapping of general and thematic wetlands is done by assigning expert rules for how to combine hydromorphology, the satellite derived compound Transformed Wetness Indexes, and the Wetland Topographic Convergence Indexes. In other words, the mapping of wetlands combines information on land form, and annual surface wetness captured both from satellite images and from a hydrological and topographic model. This information can be combined to represent different wetlands types.

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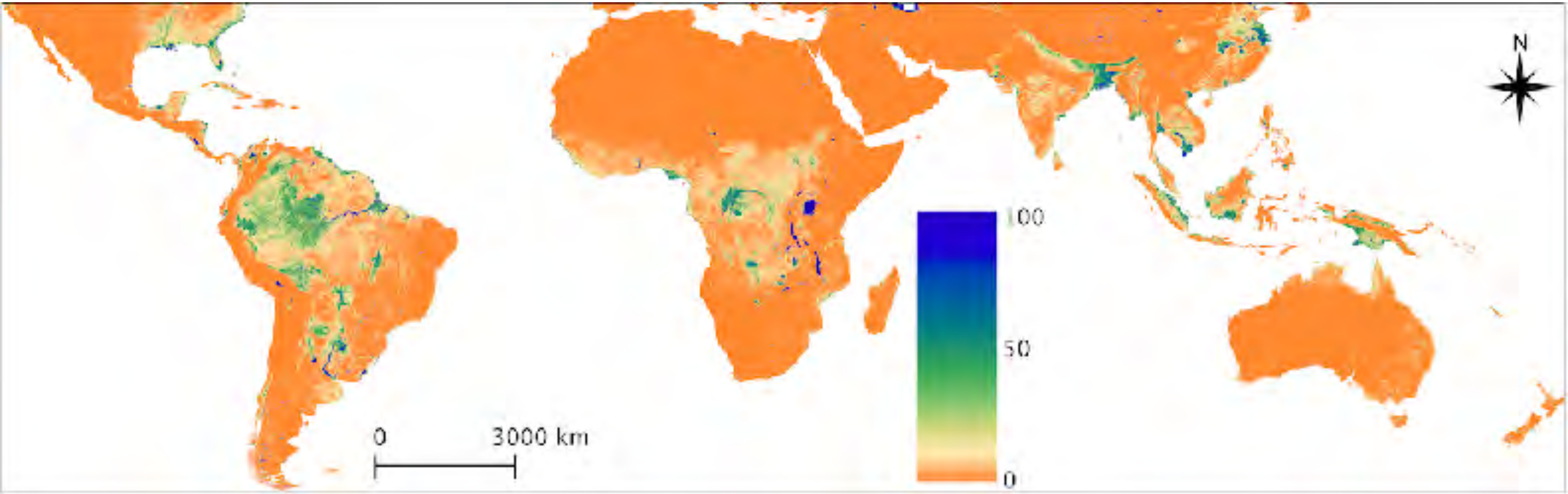
Hybrid wetland scores - global



Global wetland scores derived by combining satellite derived estimates of surface wetness (cTWI), and runoff and flooding estimates (WTCI), restricted to the hydromorphological classes plains and valleys. Areas with a negative water balance are scored as no wetland.

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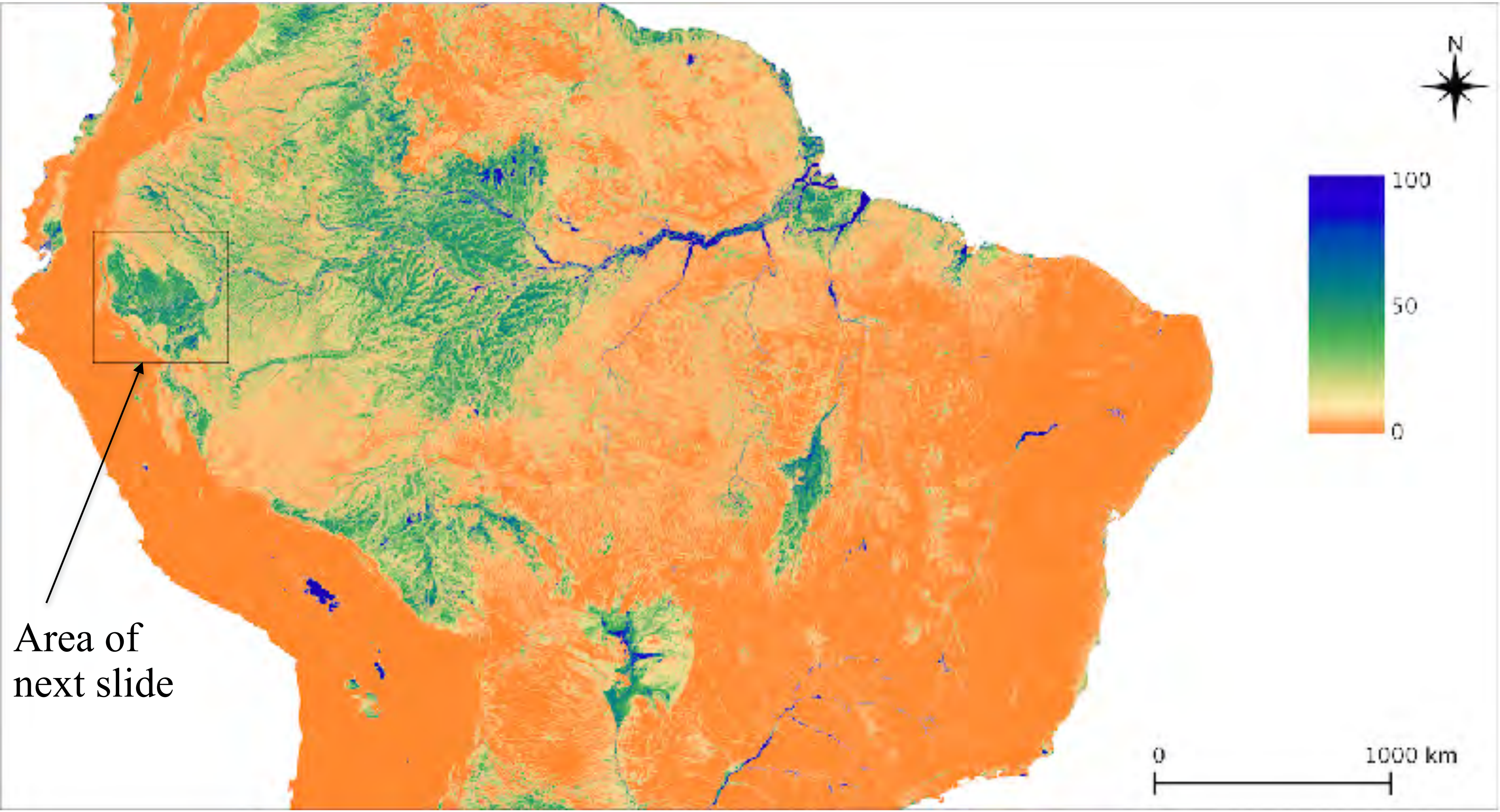
Hybrid wetland scores - South America



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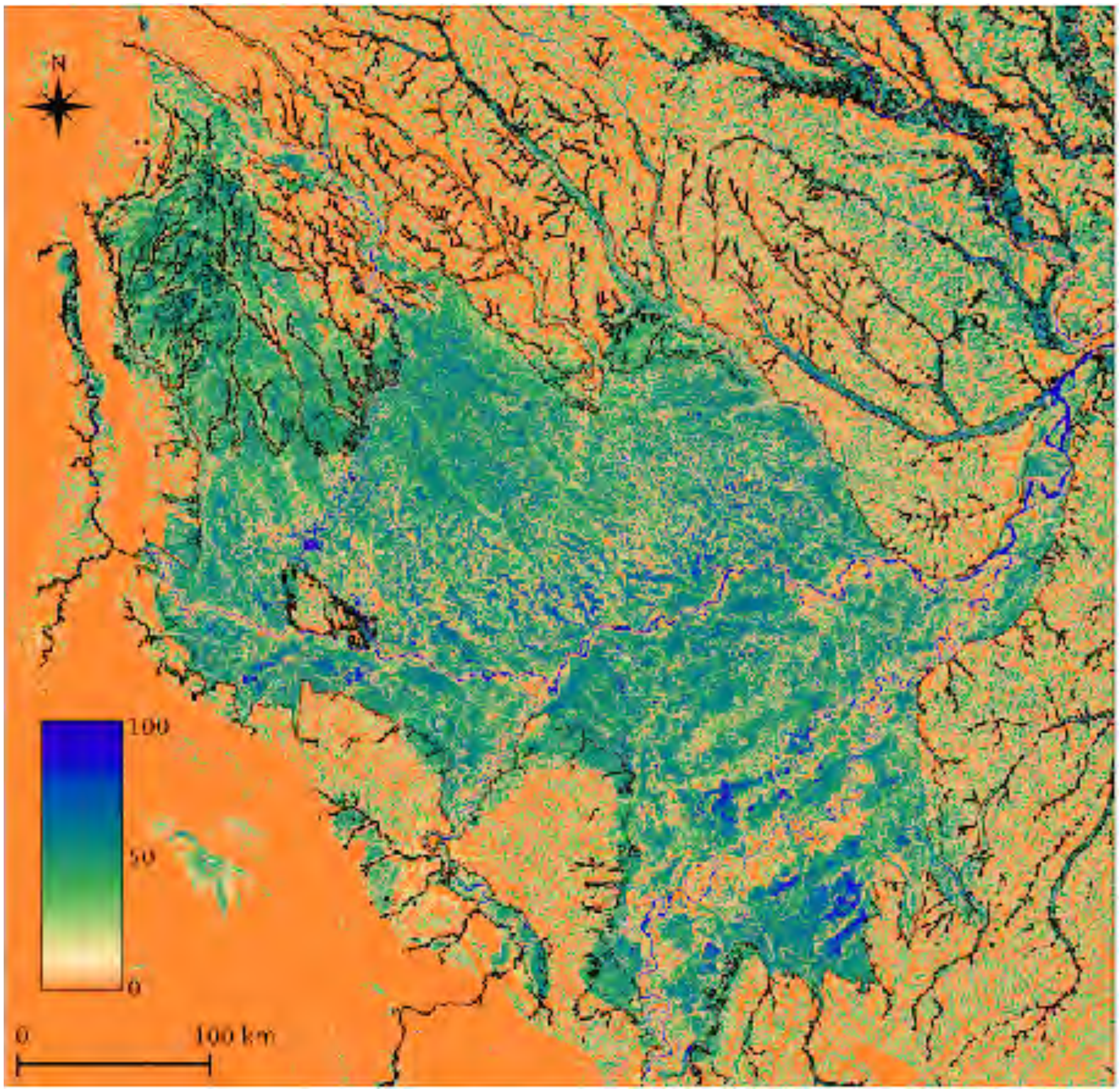
Hybrid wetland scores - Peruvian Amazon



The wetland scores for the Peruvian Amazon compared with a radar derived wetland map outlined in black (from ORNL, Hess et al. (2012).

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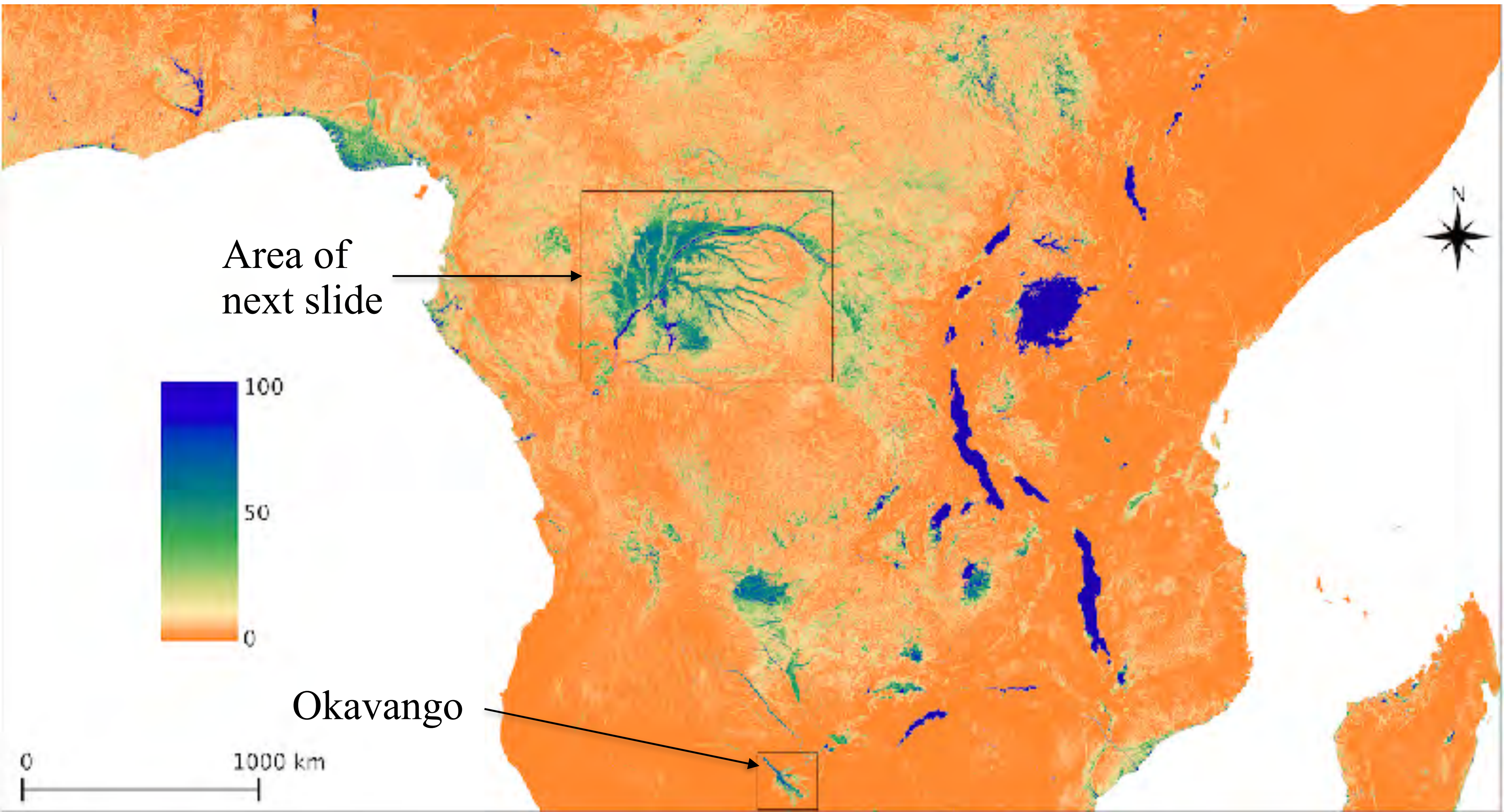
Hybrid wetland scores - Africa



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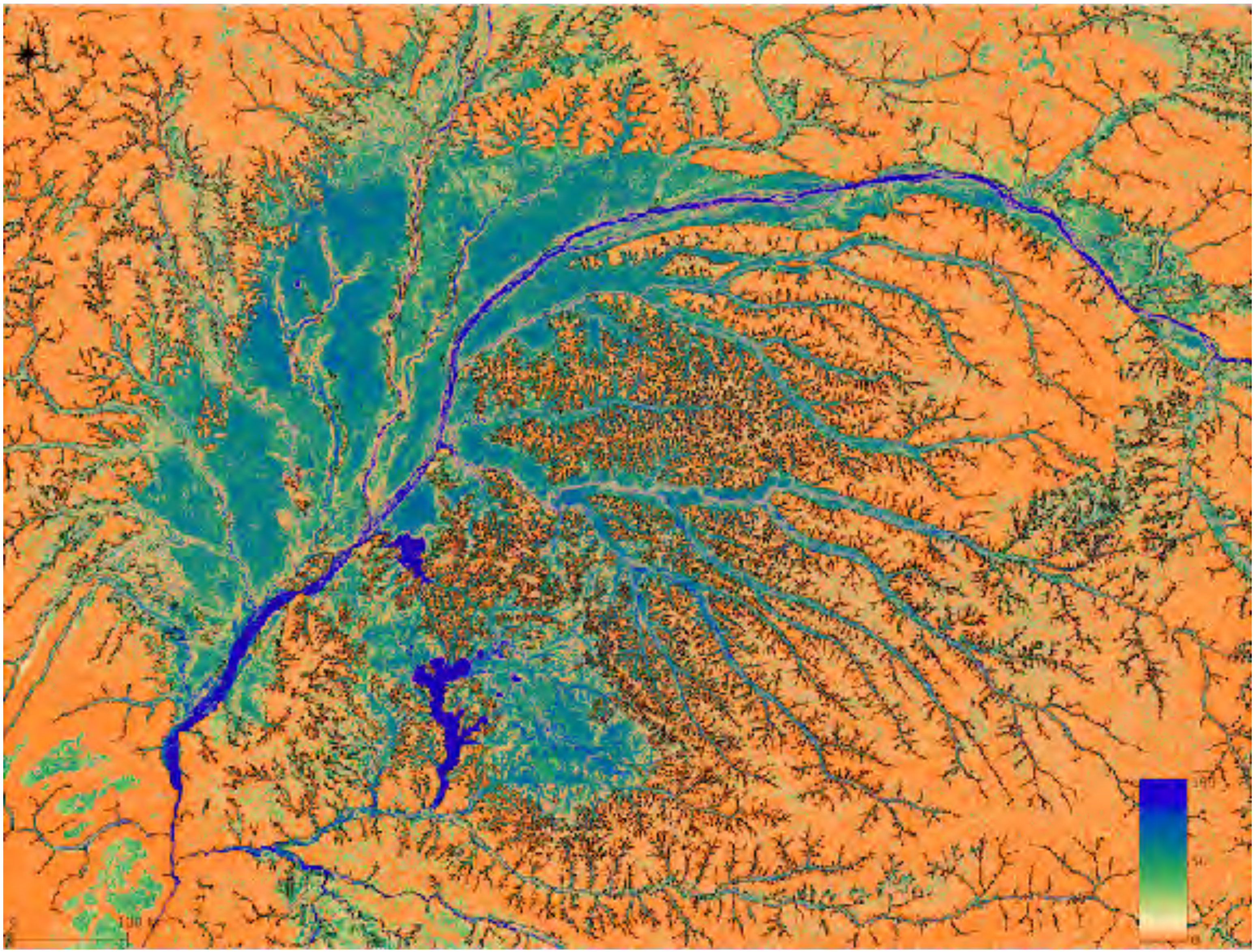
Hybrid wetland scores - Central Congo Basin



The wetland scores for the Central Congo Basin compared with a multi-source derived wetland map outlined in black (Bwangoy et al., 2010).

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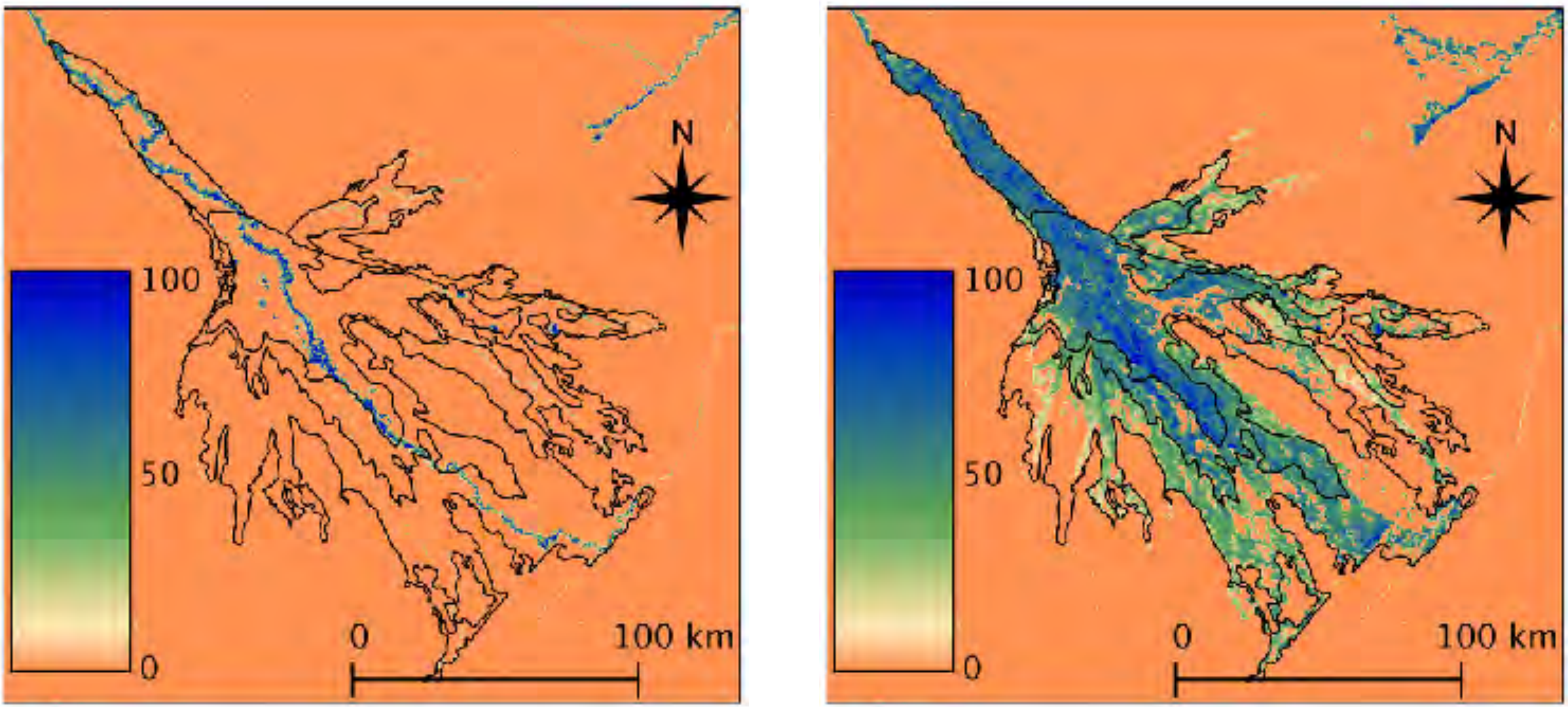
Hybrid wetland scores - Okavango



The wetland scores for the Okavango, excluding (left) and including (right) flooding, and compared with a more detailed wetland map outlined in black (McCarthy et al., 2003).

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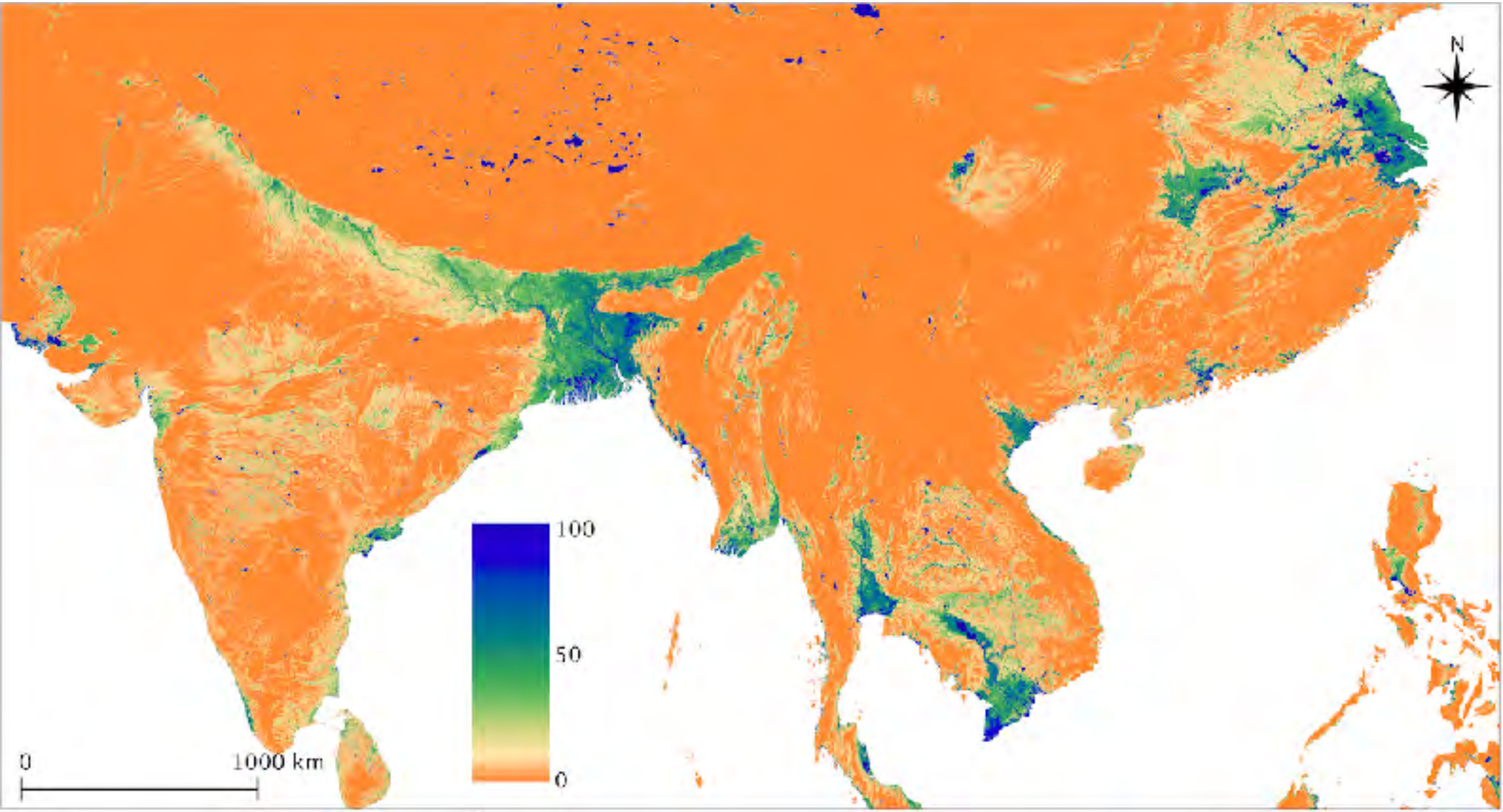
Hybrid wetland scores - Asia



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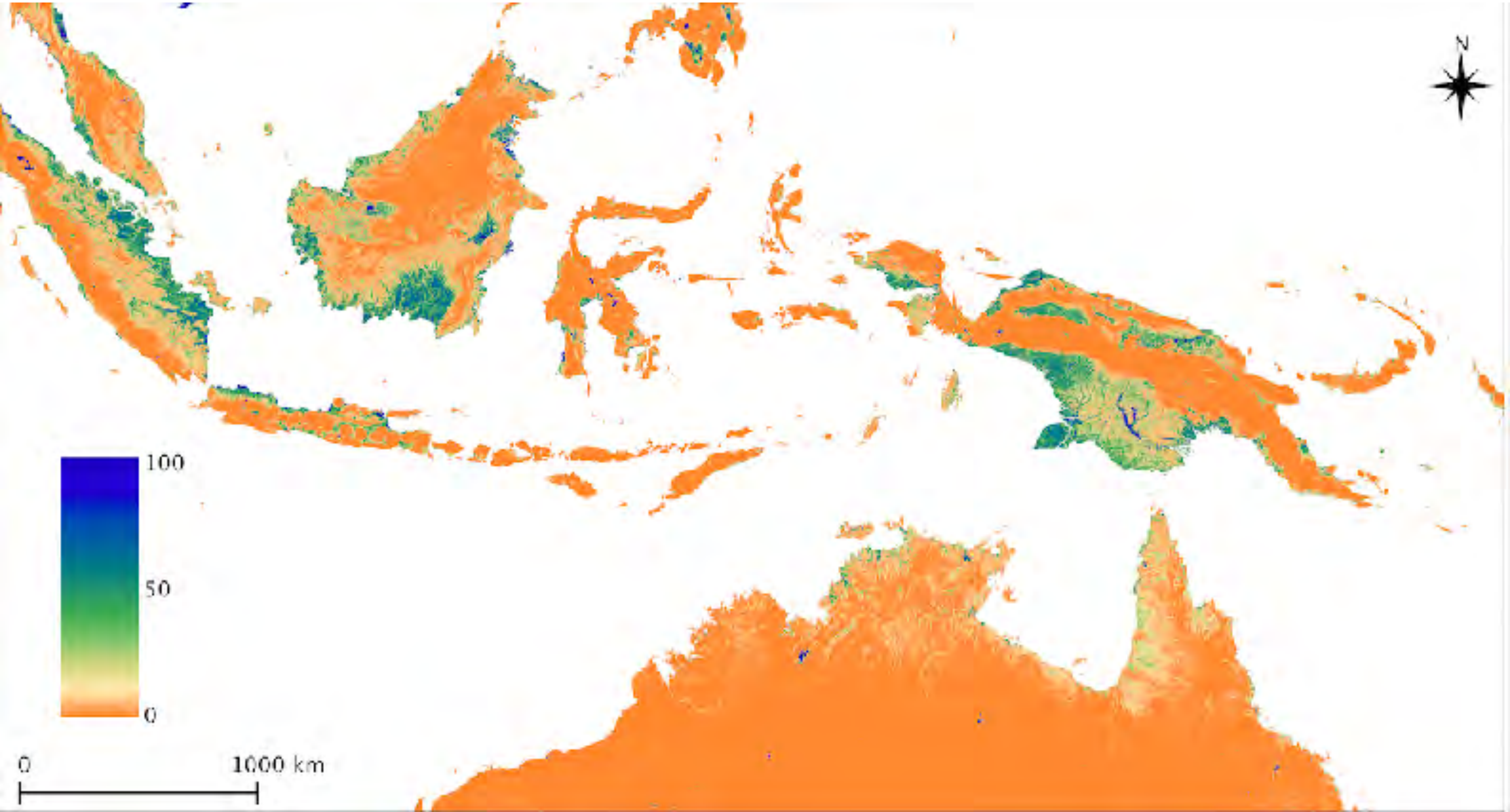
Hybrid wetland scores - South East Asia



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Peatland depth map - South East Asia

The peatland depth map was done by first altering the expert rules and only include regions with e.g. longer inundation. A threshold was set to get peatlands from the scoring, and the depth was retrieved from a map of hydraulic terrain relief (one of the hydromorphological maps).

Darker shades of green denote deeper organic horizon.

The SWAMP mapping approach

Flexible but difficult

Being based on intelligible maps that capture the biophysical characteristics of the lands surface, the hydrid mapping approach can be adjusted both thematically and regionally. It can be used as a system for testing hypothesis of where wetlands occur. But in its present form the system is not user friendly.

All the maps are available at CIFOR as geoTIFF files (they can be displayed and manipulated in any software that handles TIF, and become maps in a GIS program).

Mapping global tropical wetlands

Estimates of tropical wetlands and peatlands (bounded by 20º latitude)

	Total area	Volumetric area*	Total volume
	km^2	km^2	km^3
Open Water	540,000	--	--
Wetlands	4,100,000	2,700,000	10,000
Peatlands	2,100,000	1,500,000	7,100

*The volumetric area excludes all cells with a recorded wetland or peatland depth equal to zero.

Using global rules and thresholds the hybrid wetland mapping approach was used for estimating the extent and volumes of global tropical wetlands and peatlands.

Mapping global tropical wetlands

Next steps - map validations

Only bits and pieces of the biophysical background maps have been possible to validate. There is simply a lack of consistent, quality assured and georeferenced data available. Finding, evaluating and assembling the necessary reference data has turned out to be very demanding.

The validation of the wetland/peatland map has been restricted to a few regions with either accurate maps previous published, or with reference point data. Only a minority of this reference data contain the full information on wetland type, peat occurrence, peat depth and organic carbon content.

Mapping global tropical wetlands

Conclusion

- The hybrid wetland classification model does not depend on reference data, but is an expert approach.
- Results are consistent but depend on the quality of the input data.
- Local and regional calibration relating to e.g. climatic water balances and geomorphological conditions can be used to improve the classification accuracy.
- The biophysical background maps can be used as input also for other thematic map compilations

Mapping global tropical wetlands

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References:

Bwangoy, J.-R. B., M. C. Hansen, D. P. Roy, G. De Grandi and C. O. Justice. 2010. Wetland Mapping in the Congo Basin Using Optical and Radar Remotely Sensed Data and Derived Topographical Indices. *Remote Sensing of Environment* 114(1): 73–86.

Hess, L. L., J.M. Melack, E.M.L. Novo, C.C.F. Barbosa and M. Gastil. 2012. LBA-ECO LC-07 JERS-1 SAR Wetlands Masks and Land Cover, Amazon Basin: 1995-1996. Oak Ridge. doi:http://dx.doi.org/10.3334/ORNLDAAC/1079

McCarthy, J. M., T. Gumbricht, T. McCarthy, P. Frost, K. Wessels and F. Seidel. 2003. Flooding Patterns of the Okavango Wetland in Botswana between 1972 and 2000. AMBIO, 32(7): 453-457.