A surface water body dataset with daily temporal resolution: Selected examples and application potential of the Global WaterPack

Igor Klein, Ursula Gessner, Andreas Hirner, Andreas Dietz, Stefan Dech, Claudia Kuenzer

MWBS

Mapping Water Bodies from Space 2nd conference

27-28 March 2018, ESA-ESRIN, Frascati, Rome (Italy)

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Arctic spring is starting 16 days earlier than a decade ago, study shows

Climate change is causing the season to start comparatively earlier the further north you go, say scientists

Biodiversity

The average first freeze over the last 10 years, from 2007 to 2016, is a week later than the average from 1971 to 1980, which is before Kunkel said the trend became noticeable.

But while the calendar stays the same, the seasons seem to be changing. As the planet warms, spring has been springing earlier. A 2009 study in *Nature* estimated that spring now comes about 1.7 days earlier than it did during the first half of the 20th century.

Flooding

Agriculture

Climate Impact

Recent Development

Static & Global

- ESA CCI Global Water Bodies 300m (Defourny et al. 2013)
- MODIS 250m water-mask (Carroll et al., 2009)
- GLWD, 2004 (Lehner and Döll 2004)
- GLOWABO, 14.25m (Verpoorter et al., 2014)
- Global Land Surface Water Dataset, 30m (Chen et al., 2011)

Dynamic & Global

- AVHRR monthly inundation, 0.25° 1993-2004
  (Papa et al. 2007, 2010; Prigent et al., 2007, 2012)
- GloboLakes, 0,05° (1000 lakes)

Cluster in Permanent & Seasonal

- G3WBM, 90m (Yamazaki et al., 2015)
- GIEMS-D15, 500m (Fluet-Chouinard et al., 2015)

Regional / Local e.g.:

- Fichtelmann & Borg 2012, 2014
- Feng et al., 2012
- Klein et al., 2014
- Pekel et al., 2014
- Müller et al., 2015
- Tulbure et al., 2016

Global

- Pekel et al., 2016
- Klein et al., 2017

Global Flood Services

- e.g. NRT Global Flood Mapping (NASA)
- e.g. GDACS - Global Flood Detection System (JRC)

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Global WaterPack


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Global WaterPack – A 250 m resolution dataset revealing the daily dynamics of global inland water bodies

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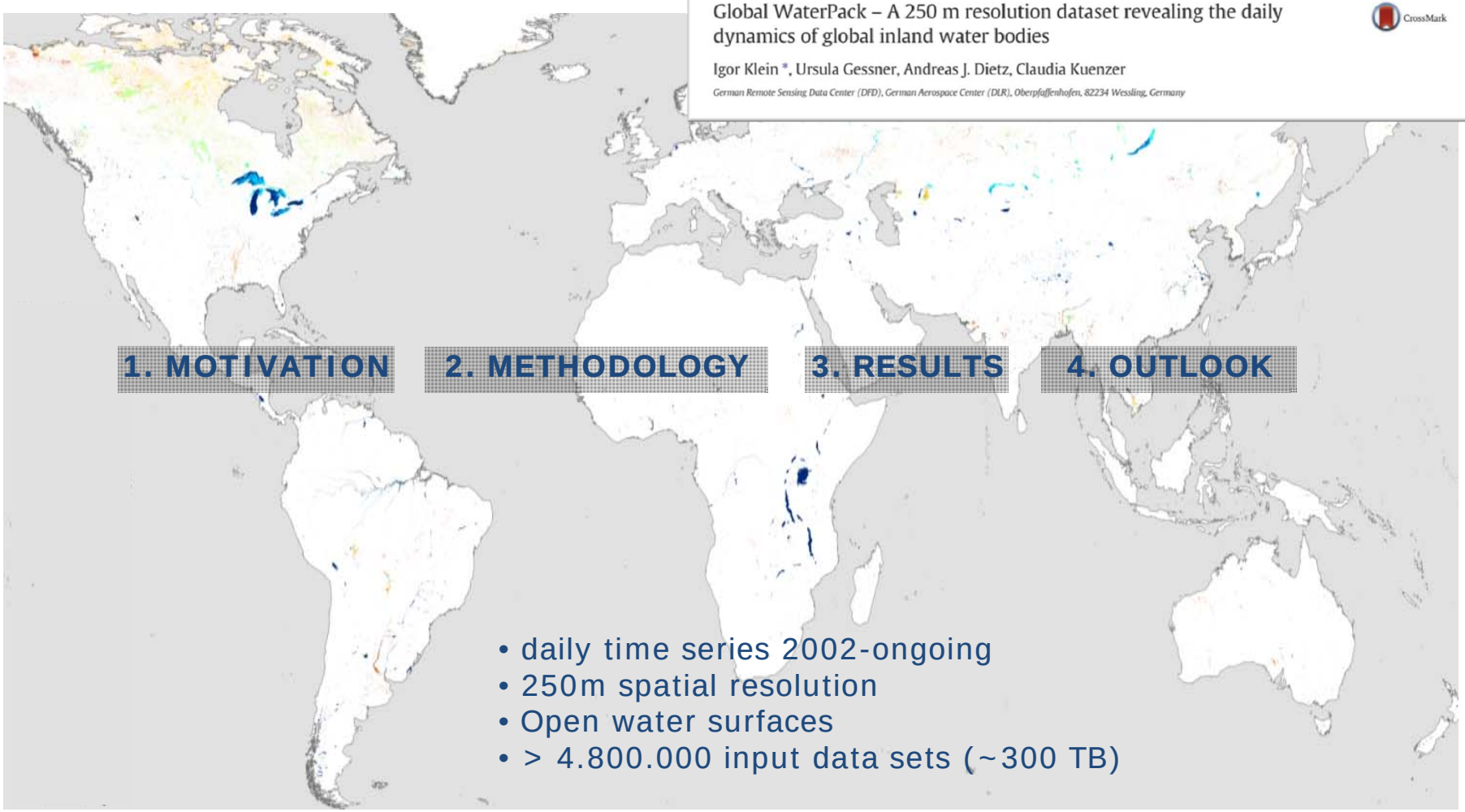

1. MOTIVATION **2. METHODOLOGY** **3. RESULTS** **4. OUTLOOK**

- daily time series 2002-ongoing
- 250m spatial resolution
- Open water surfaces
- > 4.800.000 input data sets (~300 TB)

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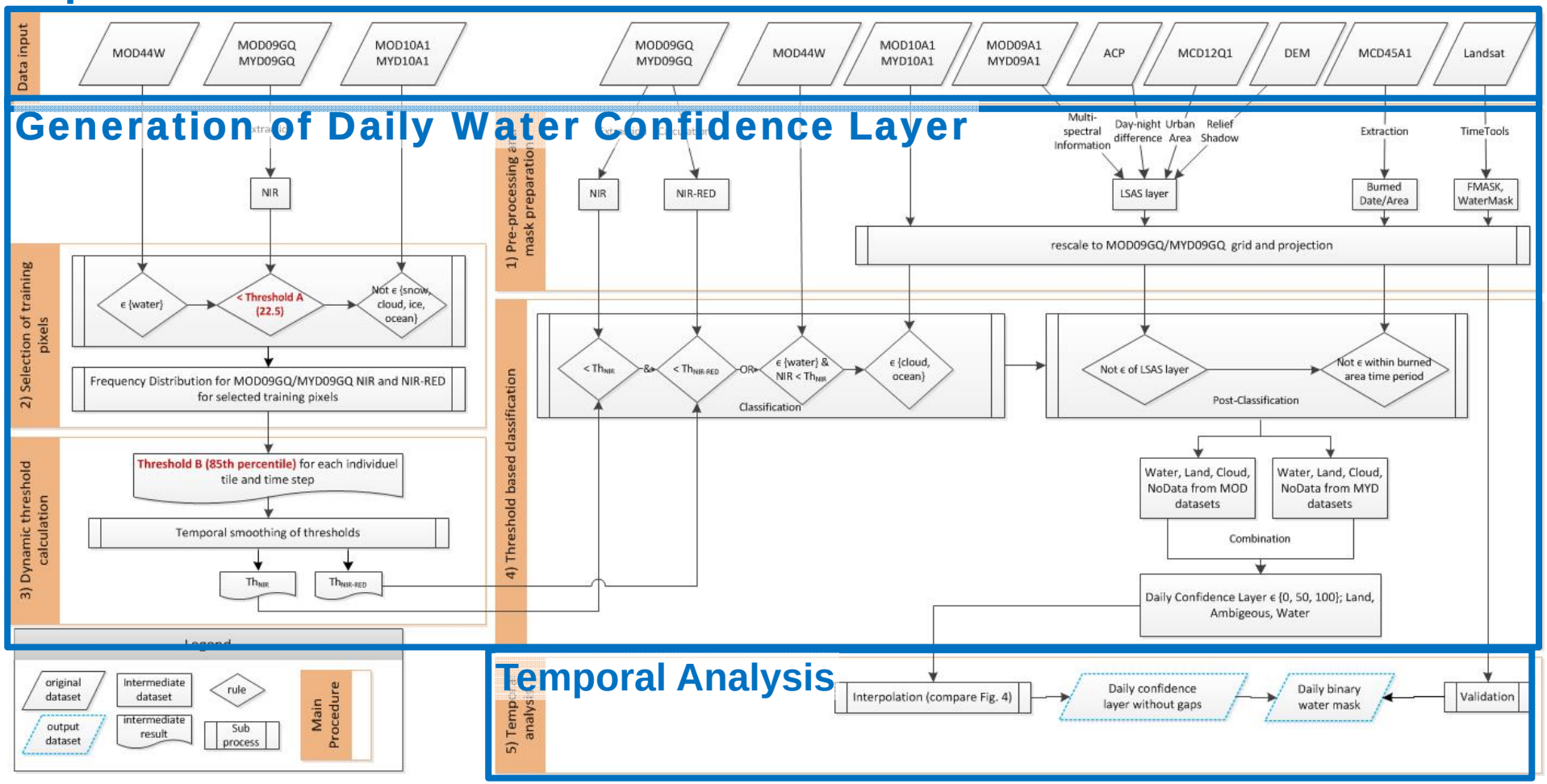
Global WaterPack – Overview Methodology

Input Data



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Input Data

- **MODIS Surface** Reflectance **(MOD09GQ/MYD09GQ)**
  - **NIR and RED**
  - **spatial resolution: 250m**
  - **temporal resolution: daily**
- MODIS Water Mask (MOD44W)
  - binary static water mask
  - spatial resolution: 250m
- MODIS Snow Cover (MOD10A1/MYD10A1)
  - Daily snow,
  - cloud,
  - lake ice classifications & static ocean layer
  - spatial resolution: 500m
  - temporal resolution: daily
- Validation: Landsat-8
  - spatial resolution: 30m
- MODIS Land Cover (MCD12Q1)
  - annual land cover classification (2000-2013)
  - (spatial resolution: 1000m)
- Global DEM (http://www.cgiar-csi.org/)
  - SRTM + auxiliary DEMs
  - (spatial resolution: 90m)
- MODIS Surface Reflectance (MOD09A1)
  - SWIR1 and SWIR2
  - (spatial resolution: 500m)
  - temporal resolution: 8-day composites
- Burned Area (MCD45A1)
  - date of burning
  - (spatial resolution: 500m)
- LST (Bechtel et al.)
  - spatial resolution: 1km

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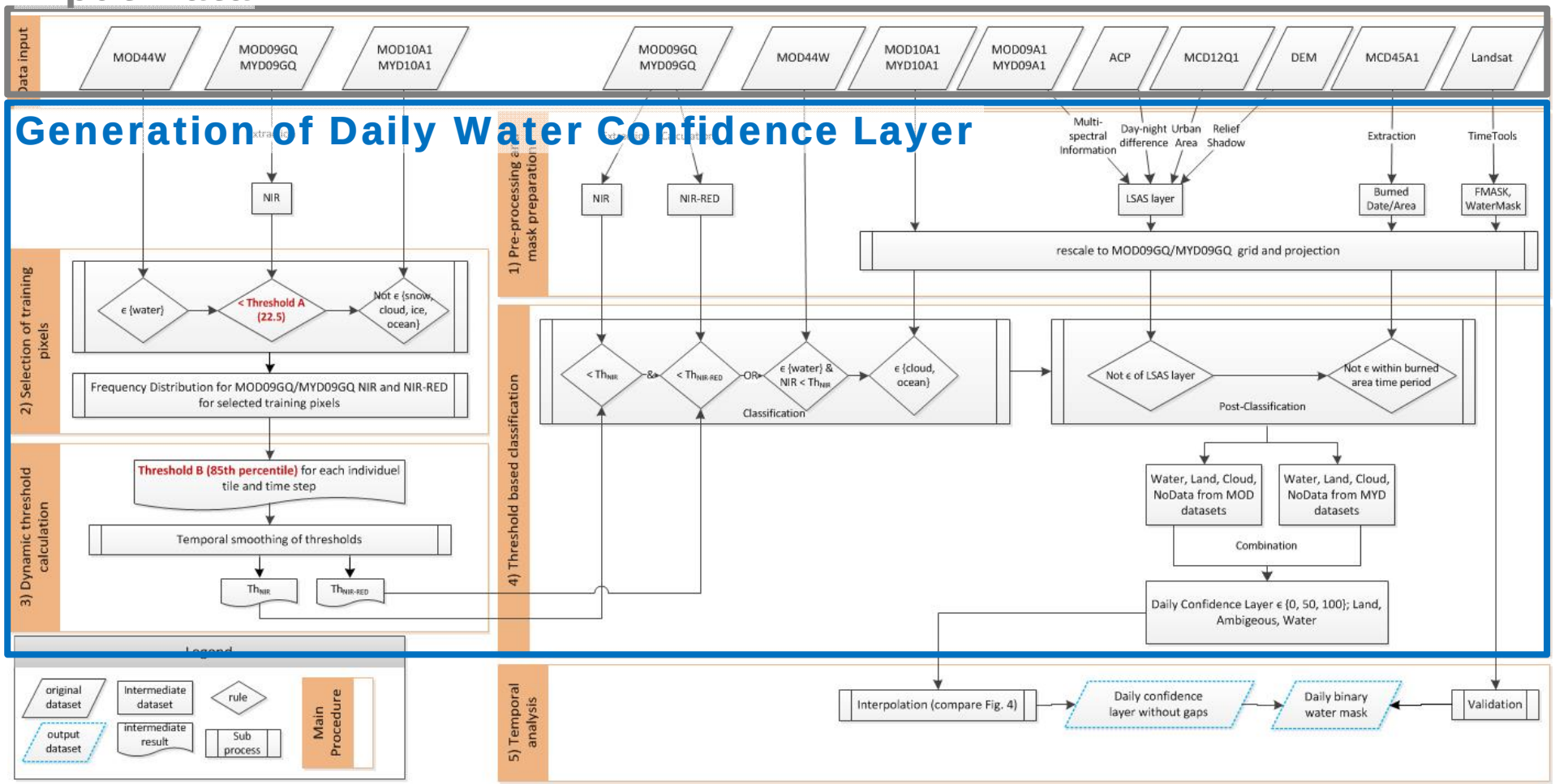
Global WaterPack – Overview Methodology

Input Data



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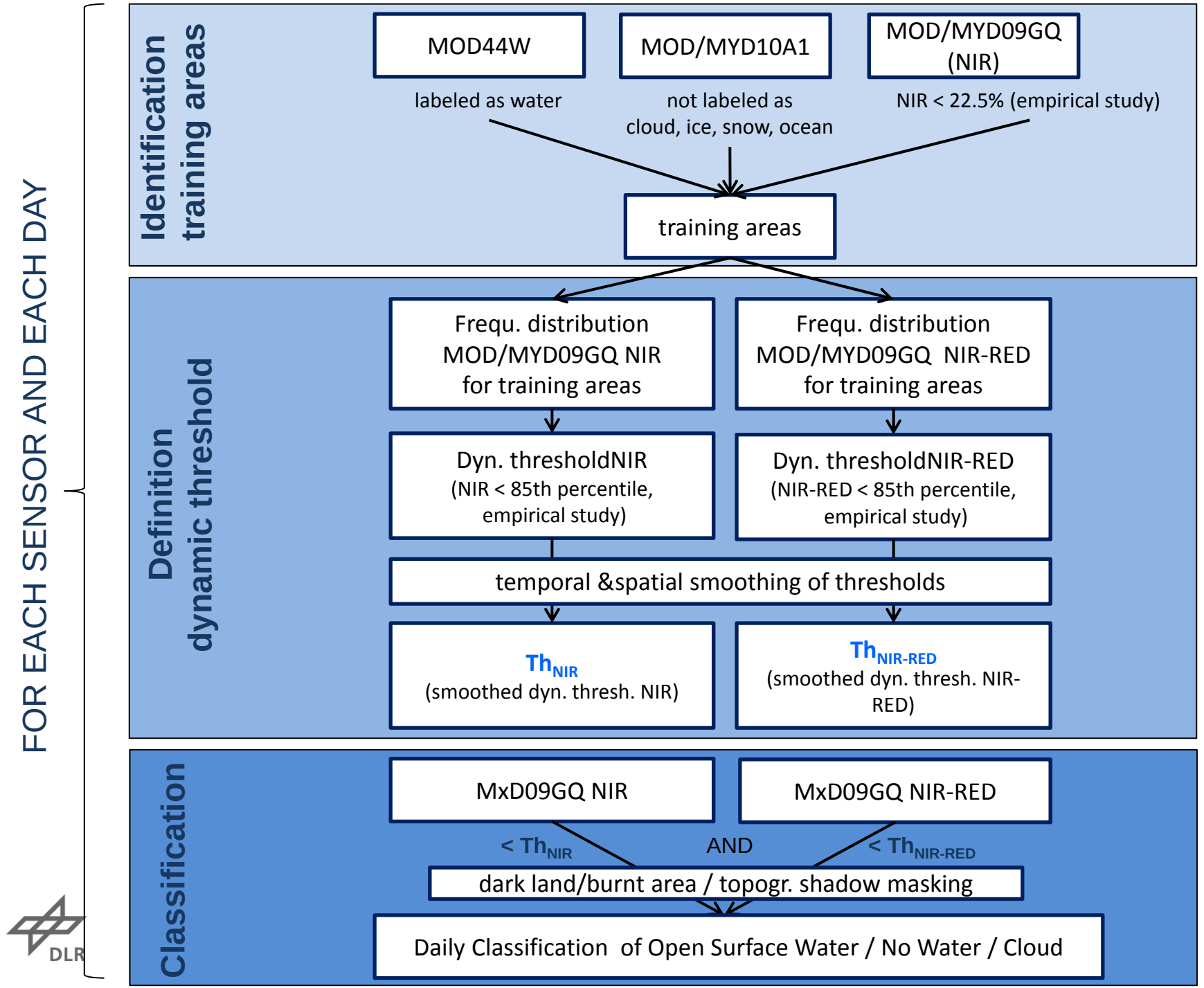
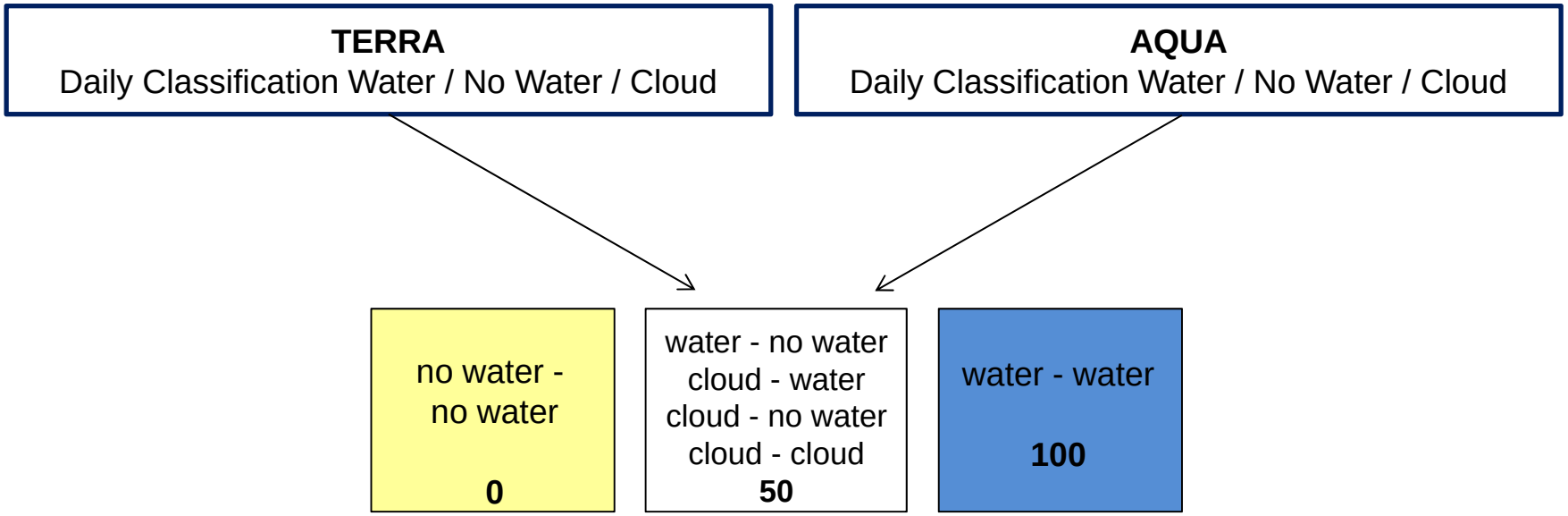
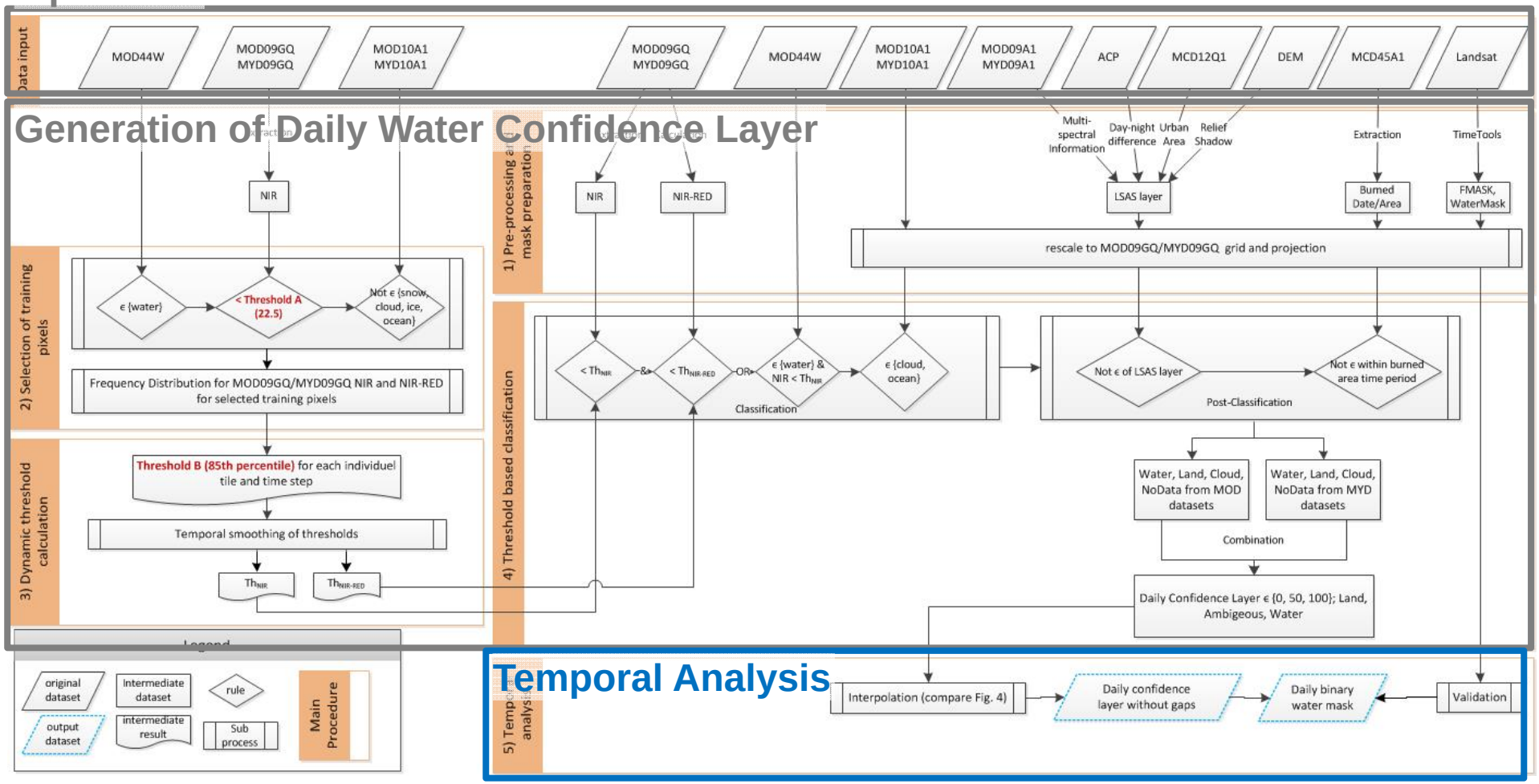

FOR EACH SENSOR AND EACH DAY
Identification training areas
MOD44W
MOD/MYD10A1
MOD/MYD09GQ (NIR)
labeled as water
not labeled as cloud, ice, snow, ocean
NIR < 22.5% (empirical study)
training areas
Definition dynamic threshold
Frequ. distribution MOD/MYD09GQ NIR for training areas
Frequ. distribution MOD/MYD09GQ NIR-RED for training areas
Dyn. thresholdNIR (NIR < 85th percentile, empirical study)
Dyn. thresholdNIR-RED (NIR-RED < 85th percentile, empirical study)
temporal &spatial smoothing of thresholds
Th NIR (smoothed dyn. thresh. NIR)
Th NIR-RED (smoothed dyn. thresh. NIR-RED)
Classification
MxD09GQ NIR
MxD09GQ NIR-RED
< Th NIR
AND
< Th NIR-RED
dark land/burnt area / topogr. shadow masking
Daily Classification of Open Surface Water / No Water / Cloud
DLR

Daily Water Classification



Global WaterPack – Overview Methodology

Input Data



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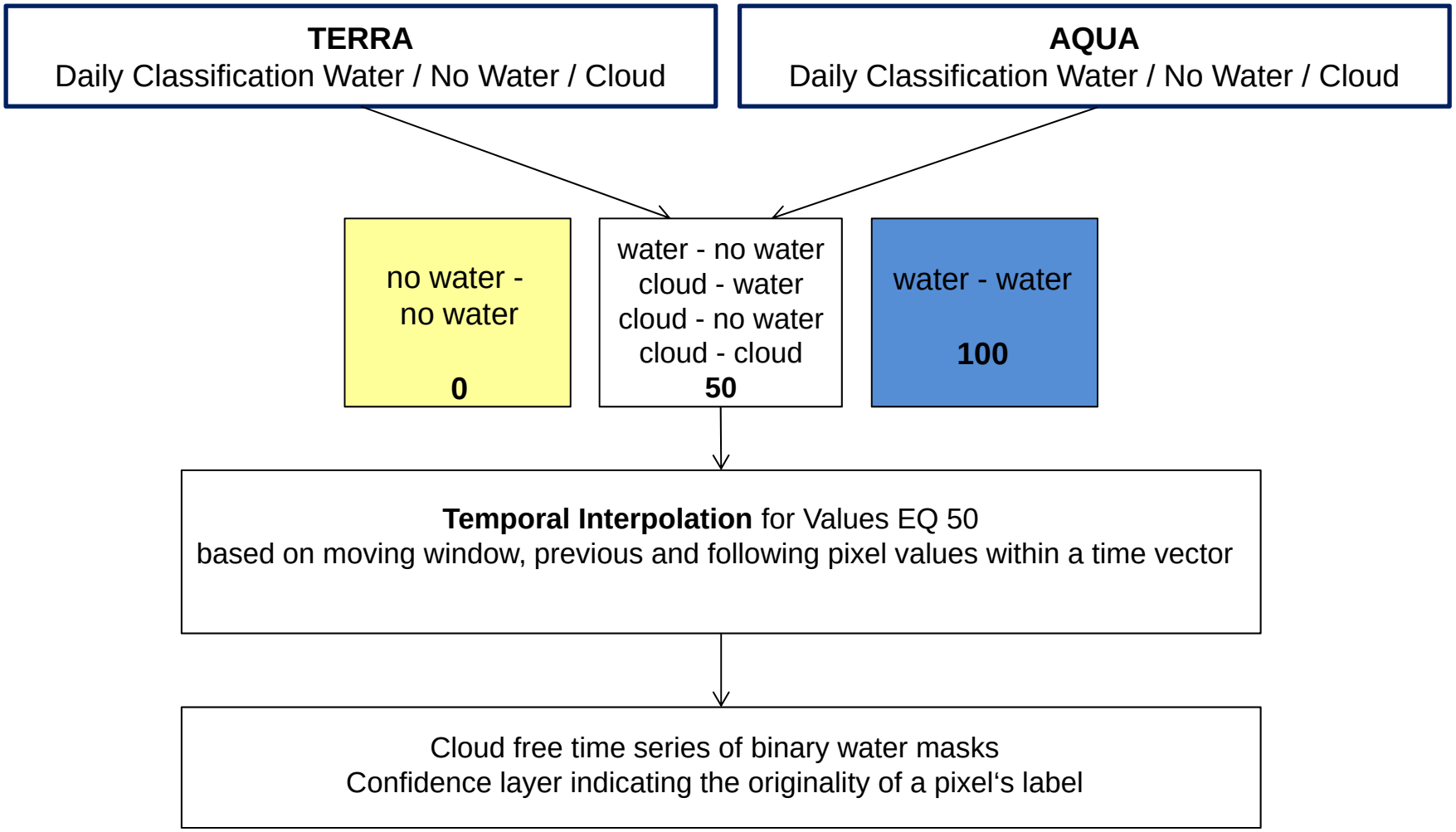
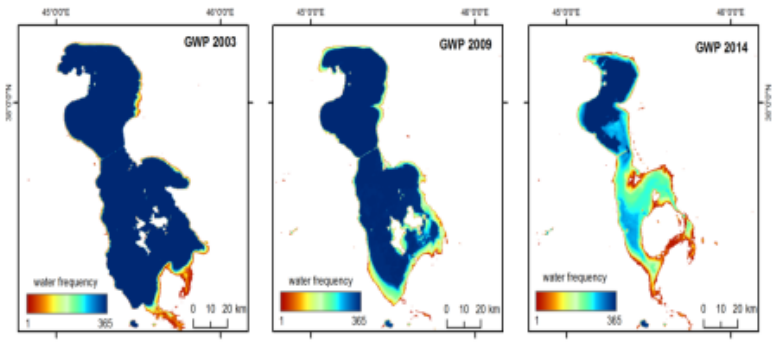
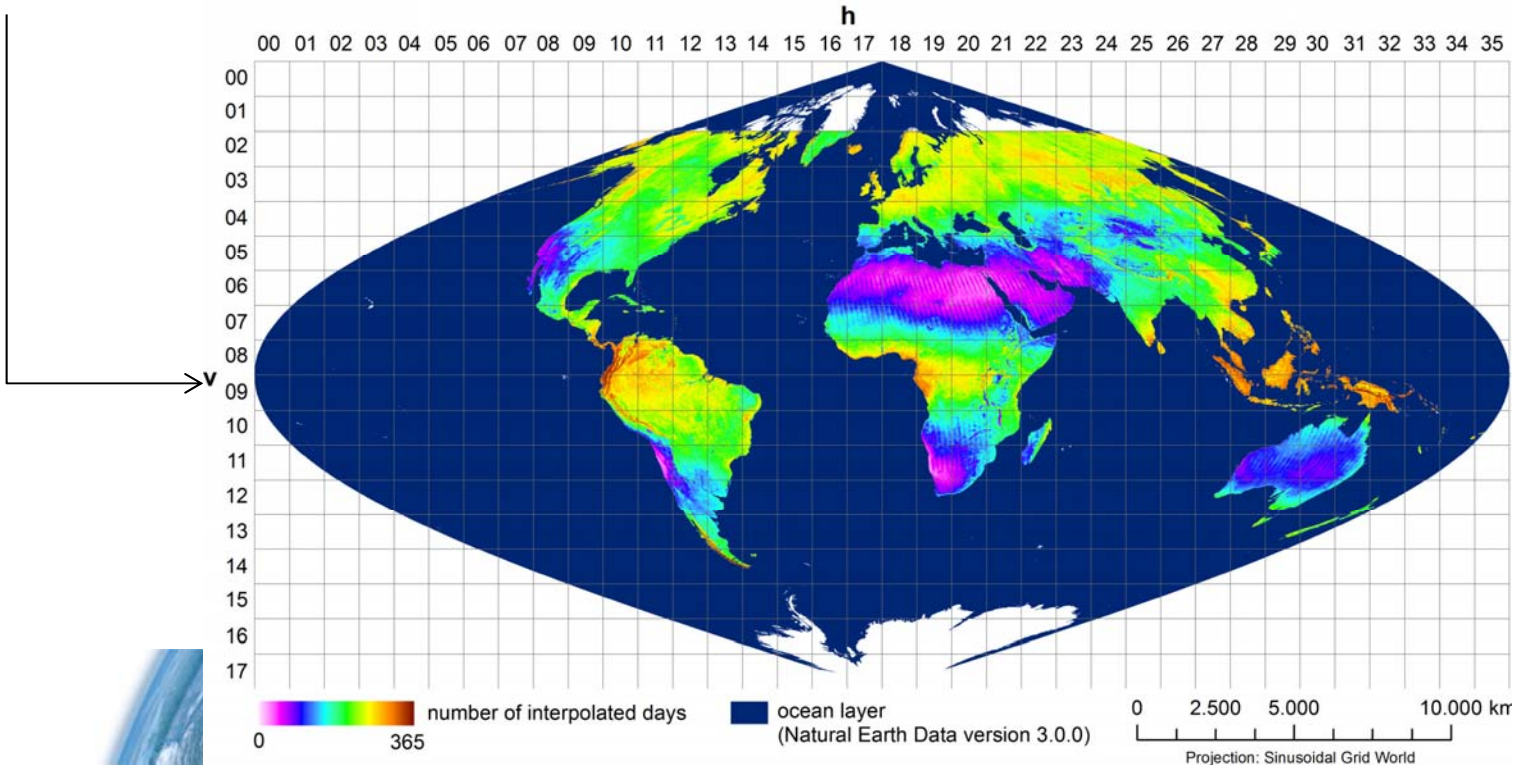
Daily Water Confidence Layer



Output Layers

- Binary Layer: Open Surface Water / No Water
- Confidence Layer: as result of temporal interpolation
- Annual sum of open surface water
- Annual sum of clouds and data gaps





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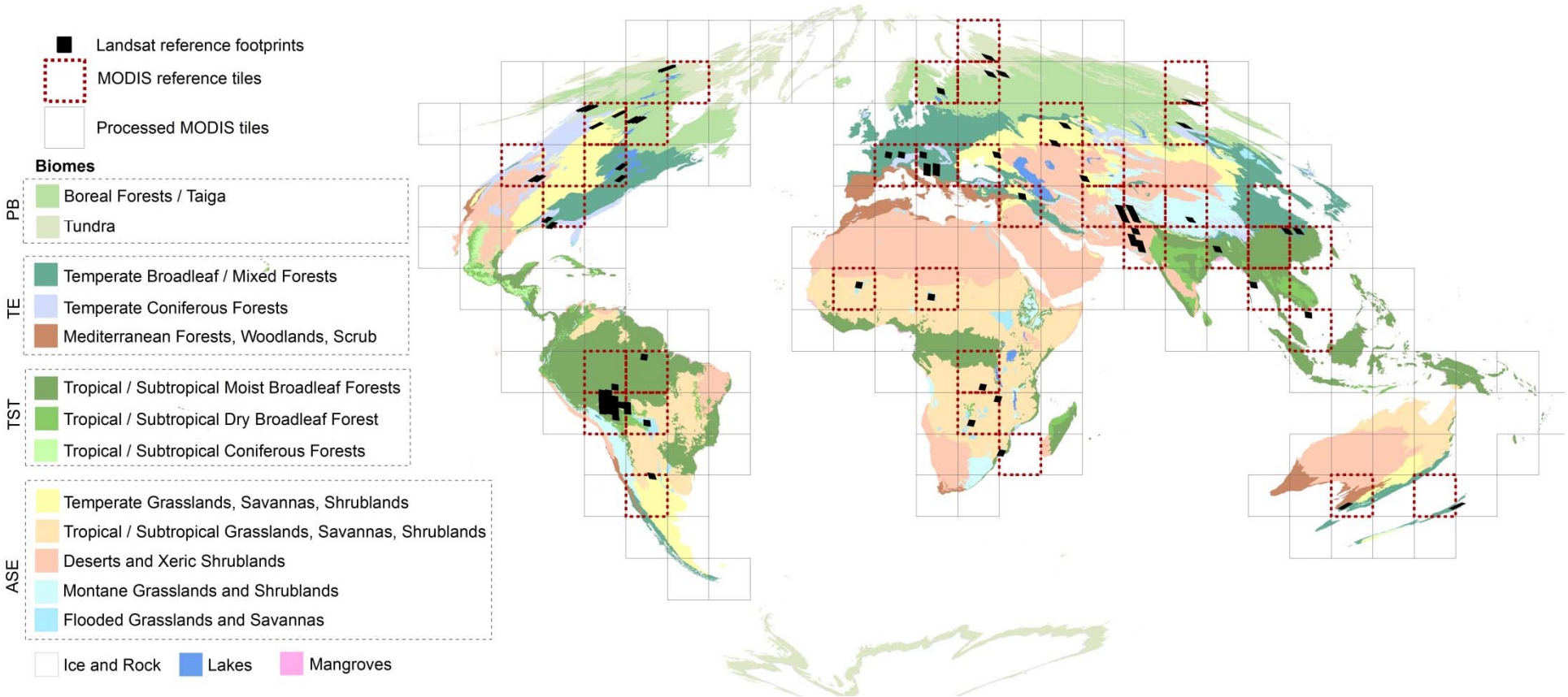
Validation with Landsat reference Data 2014

321 images, 39 footprints



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Global WaterPack – Accuracy Assessment 2014

	Sub-pixel fraction of water within MODIS 250 m pixel		
	100%	75-99.9%	50-74.9%
Omission error	7.82	20.8	72.4
Commission error	0.53	0.91	13.1
Water Map Acc.	91.7	78.5	23.1
Overall Acc.	96.3	90.1	58.7
Kappa	93.3	79.3	15.4
fScore	95.4	86.6	35.7

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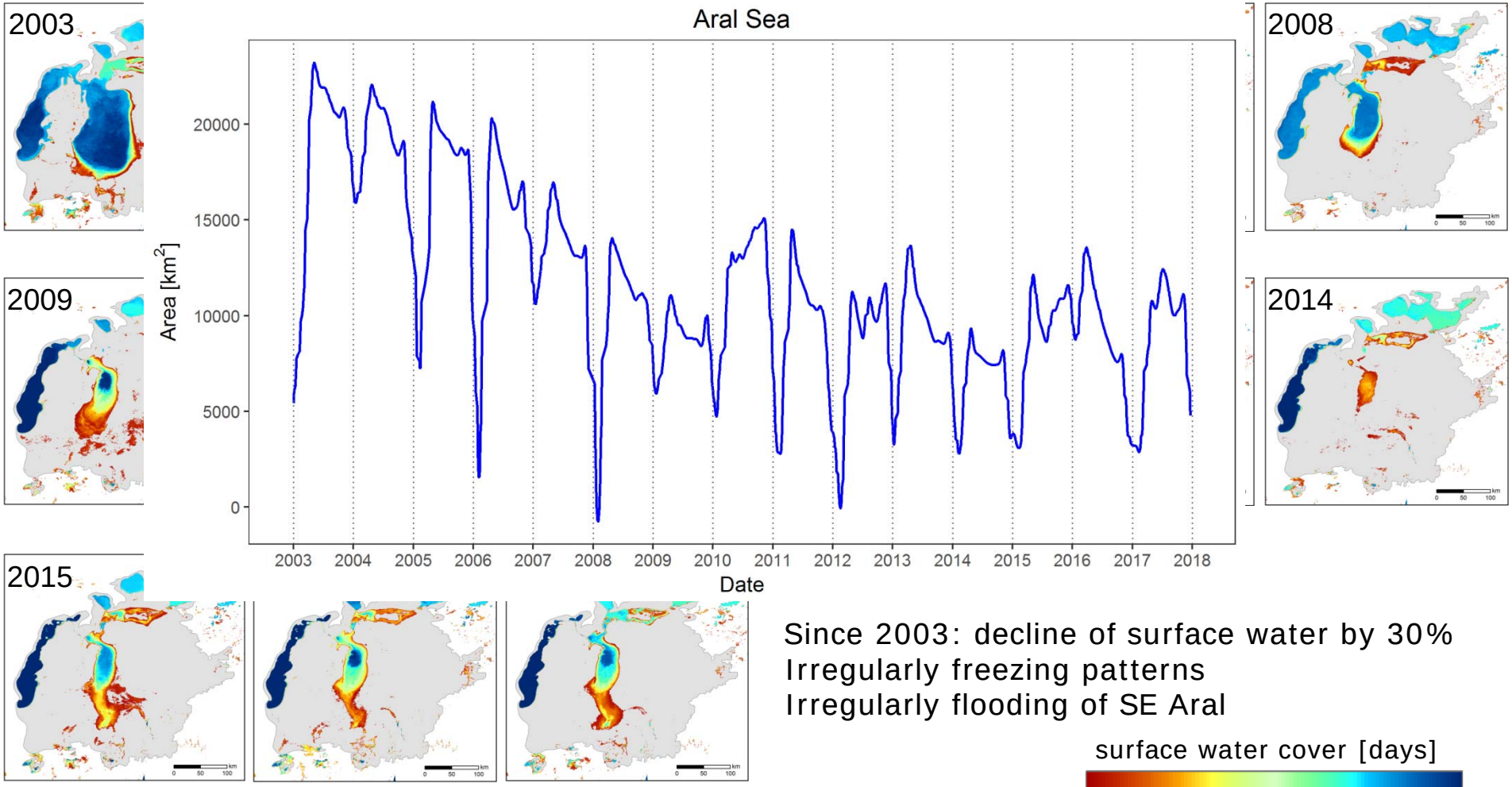
Global WaterPack – Aral Sea, KAZ / UZB



Since 2003: decline of surface water by 30%
Irregularly freezing patterns
Irregularly flooding of SE Aral

surface water cover [days]

1 365

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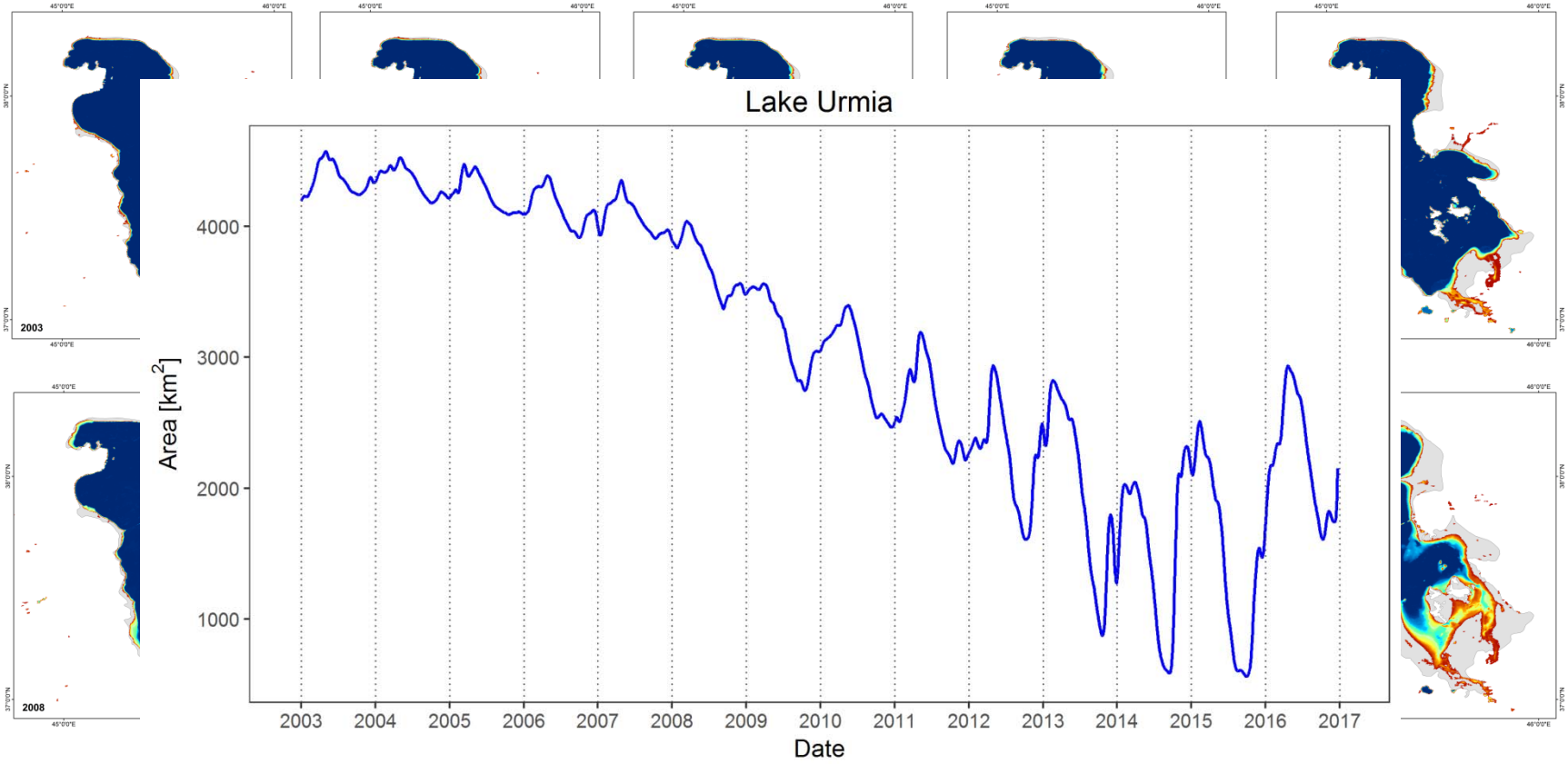
Global WaterPack – Lake Urmia, Iran



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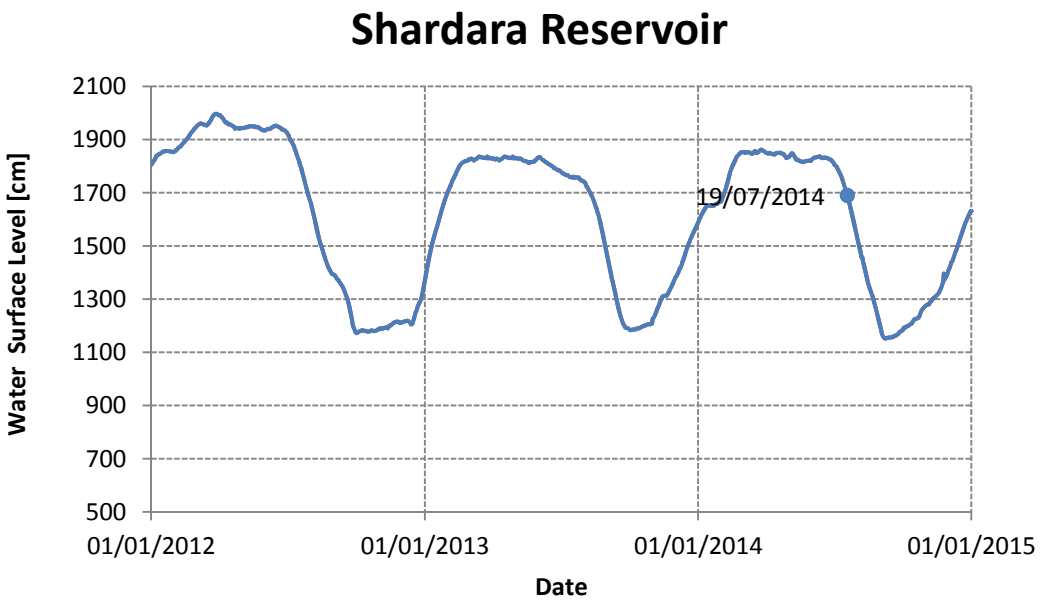
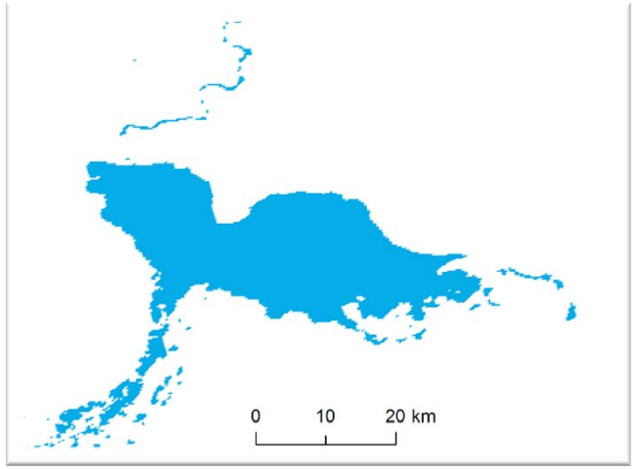
Global WaterPack – Example Shardara Reservoir





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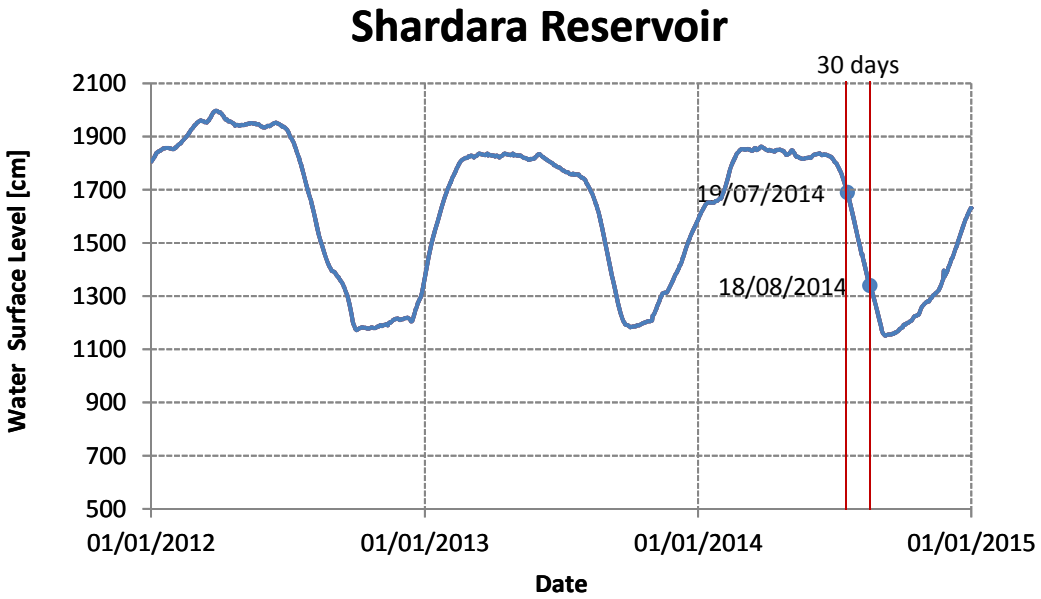

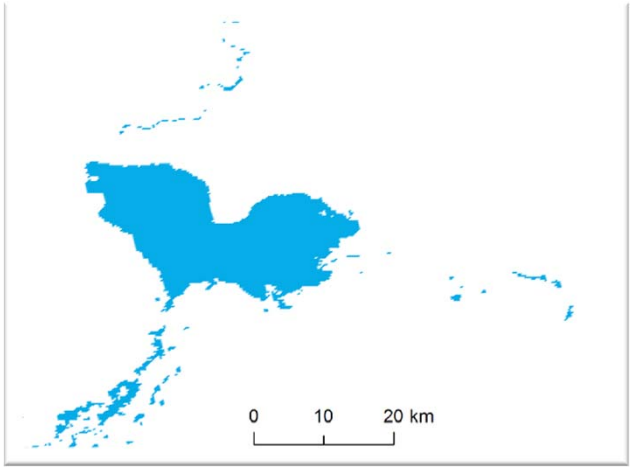

Within 30 days:

1,8 m surface level decrease

~200km² and ~30% of area decrease

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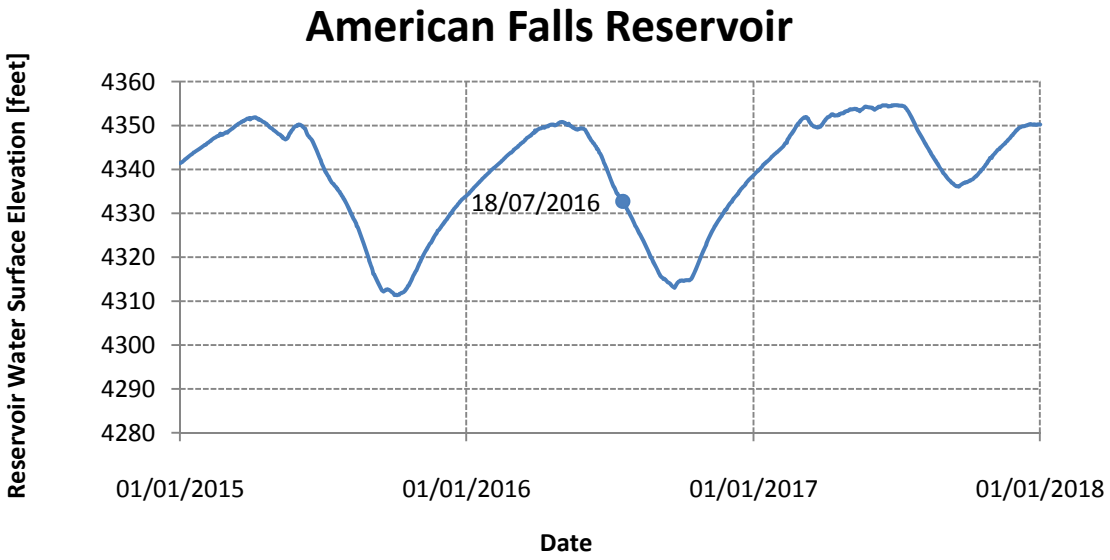
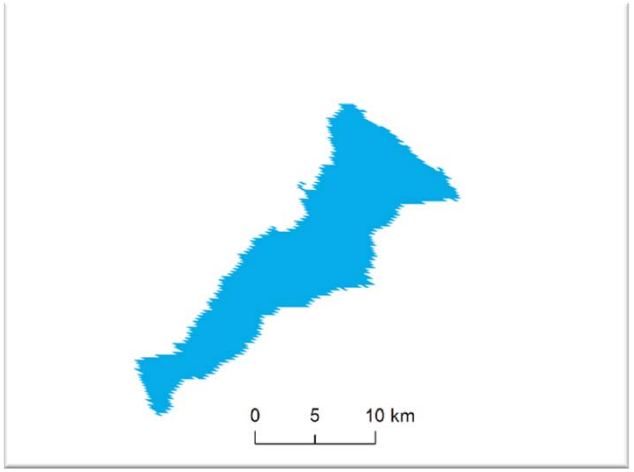
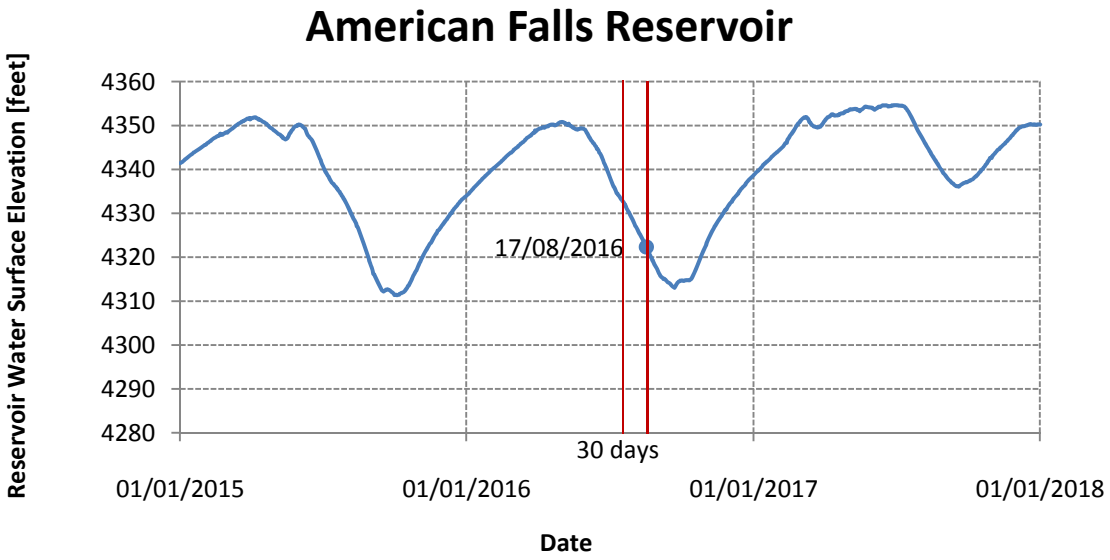
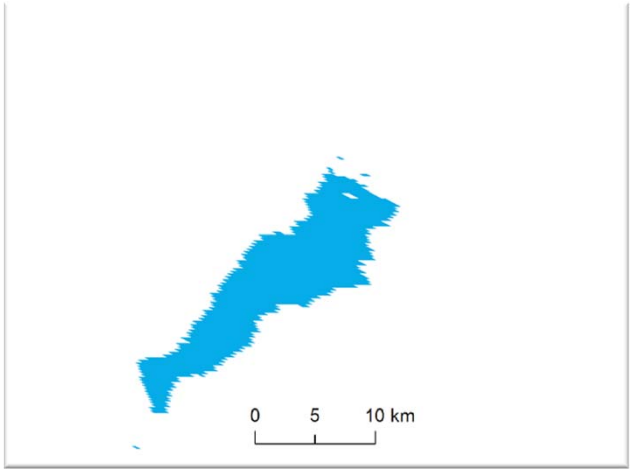
Global WaterPack – Example American Falls





Global WaterPack – Example American Falls





Within 30 days:

3 m surface level decrease

~40km² and ~25% of area decrease

Potential & Limitations

POTENTIAL

- GWP captures seasonality of flooding regimes and freezing cycles on high temporal resolution
- Detailed temporal analyses or triggers and reaction time
- Adaption to Sentinel-3 / Suomi NPP (VIIRS) -> continuity
- Adaption to Continuous Temporal Water Mapping is required (beyond NRT flood services)
- Sensor Fusion (temporal)
- Product Fusion (spatial)

LIMITATIONS

- Spatial resolution of 250 m is not satisfactory for local analyses but allows analyzing global and continental / regional patterns and trends
- GWP accounts only for open water -> permanent and seasonal water can be captured, but not inundated vegetation or water with high turbidity

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22 March 2018 According to this year's Global Risk Report by the World Economic Forum, water crises are one of the five biggest risks to society. ESA is working with development banks to help water-resource authorities use information from satellites to manage this precious resource.

How do water body dynamics impact habitats and ecosystems ?

Climate variability vs. human impact

Influence of changing weather pattern on lakes/reservoirs

e.g. Influence of El Nino/La Nina phenomena

Lake Surface Temperature and Lake Ice Phenology

Influence of armed conflicts or other abrupt interferences

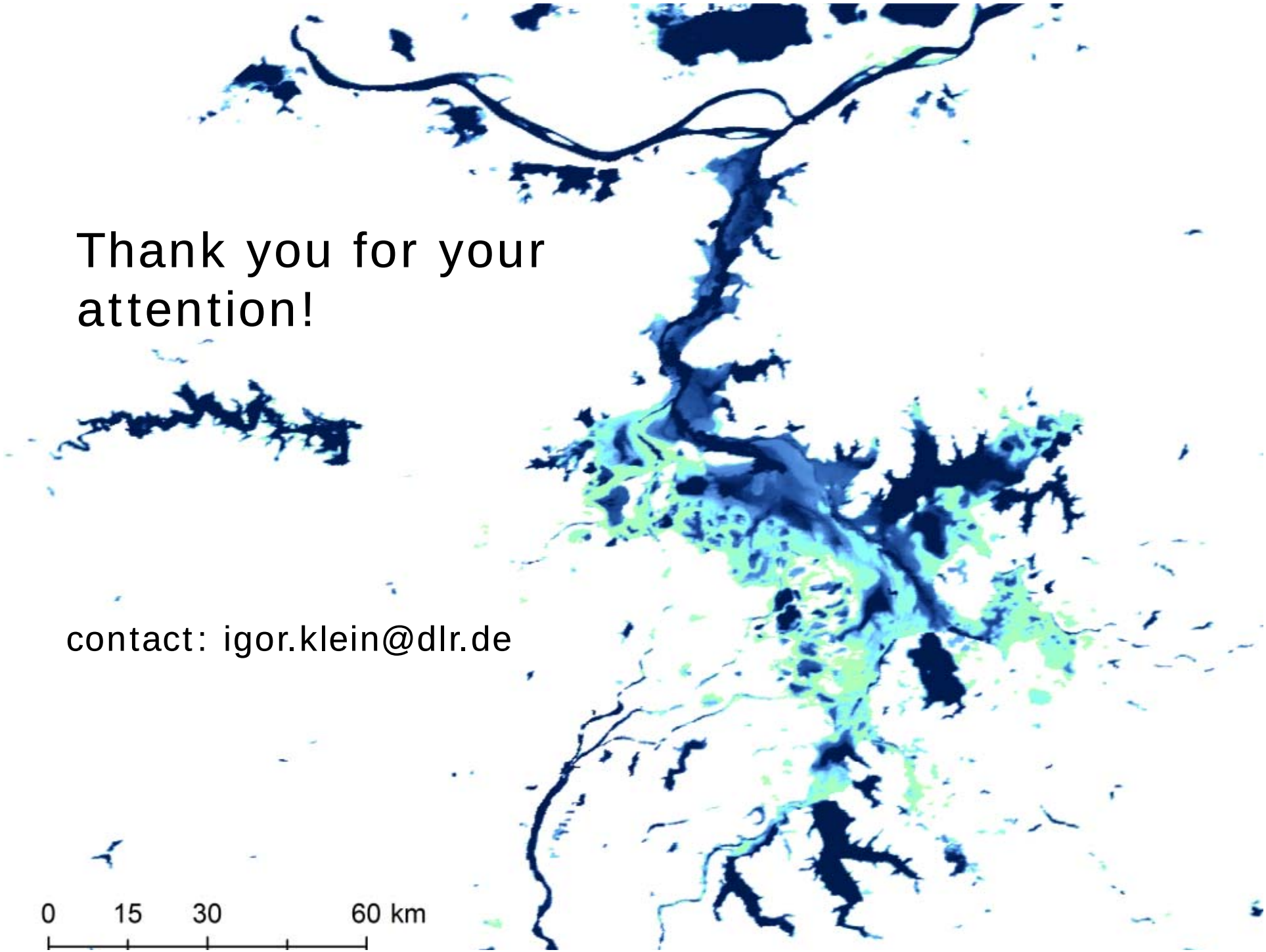
on dam management

What is the influence of hydropower dams on hinterland flooding and inundation, and on downstream localities?

How accentuated is water extent in reservoirs?

What is agriculture's impact on water availability,

also with respect to downstream demands and total production?


Thank you for your attention!
contact: igor.klein@dlr.de
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