

# The Potential of Earth Observation Time Series for the Analyses of Land Surface Dynamics

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German Remote Sensing Data Center (DFD) of the German Aerospace Center (DLR)

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Knowledge for Tomorrow

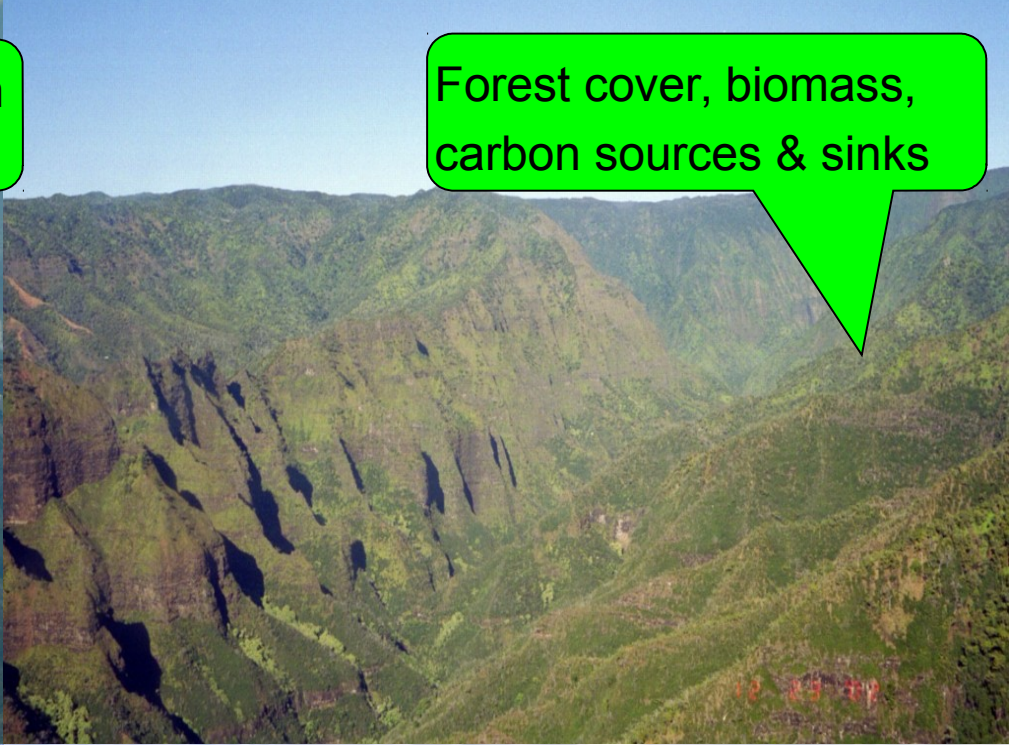






Snow cover, frozen areas, lake ice etc.

Water bodies, floods, droughts



Forest cover, biomass, carbon sources & sinks



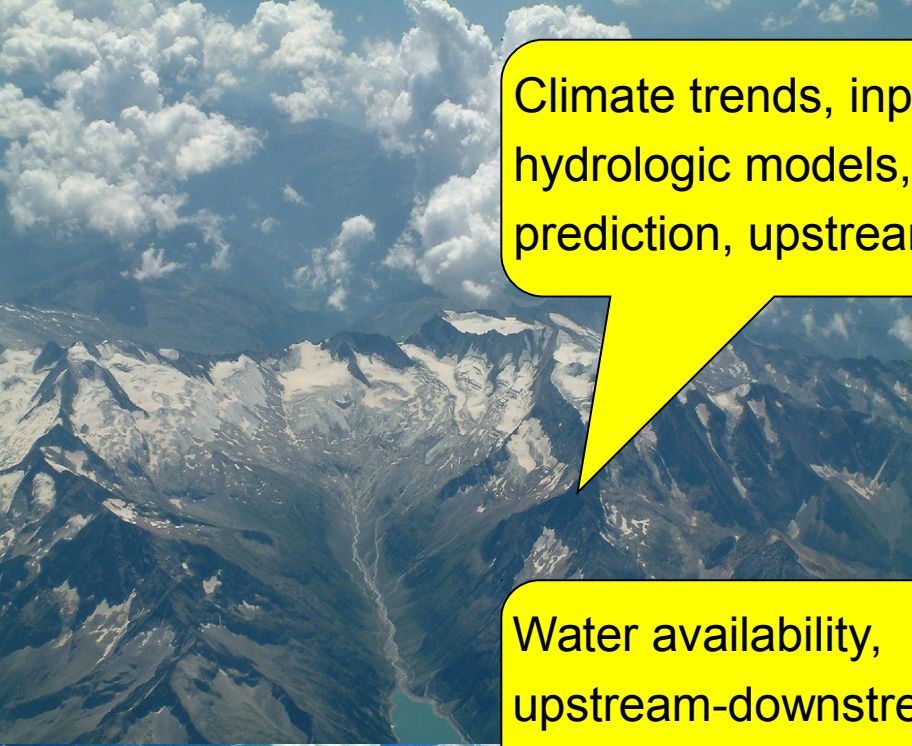
Landuse and ecosystem services



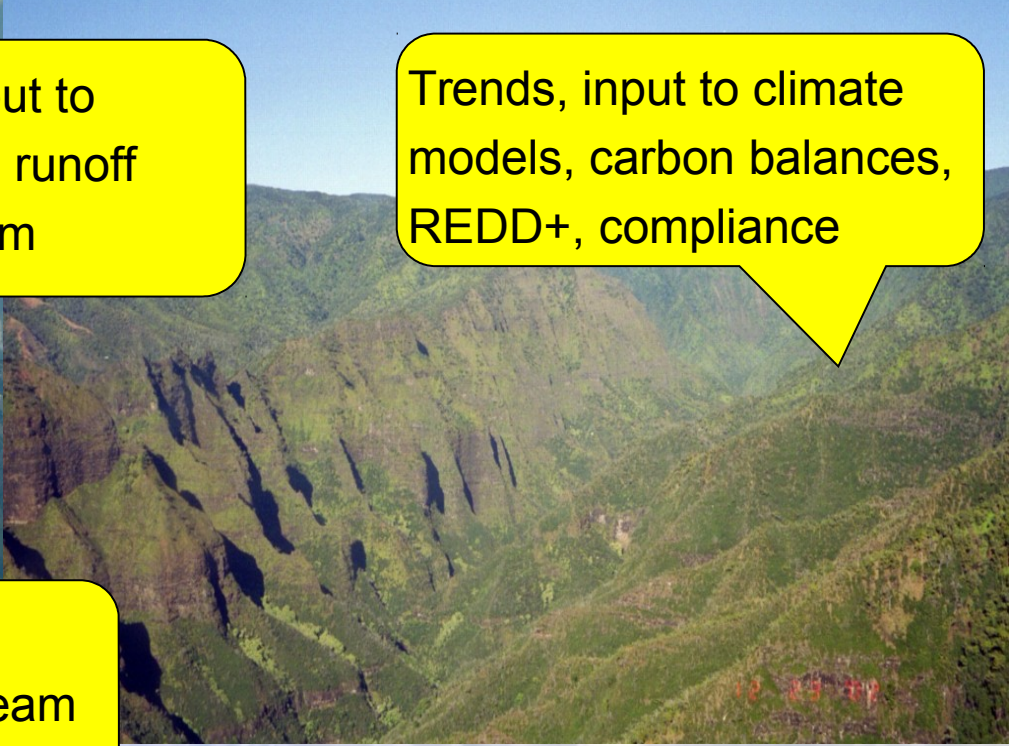
Coastal zone and delta dynamics

?





Climate trends, input to hydrologic models, runoff prediction, upstream



Trends, input to climate models, carbon balances, REDD+, compliance



Water availability, upstream-downstream conflicts, basin issues

Food security, usage conflicts, planning process



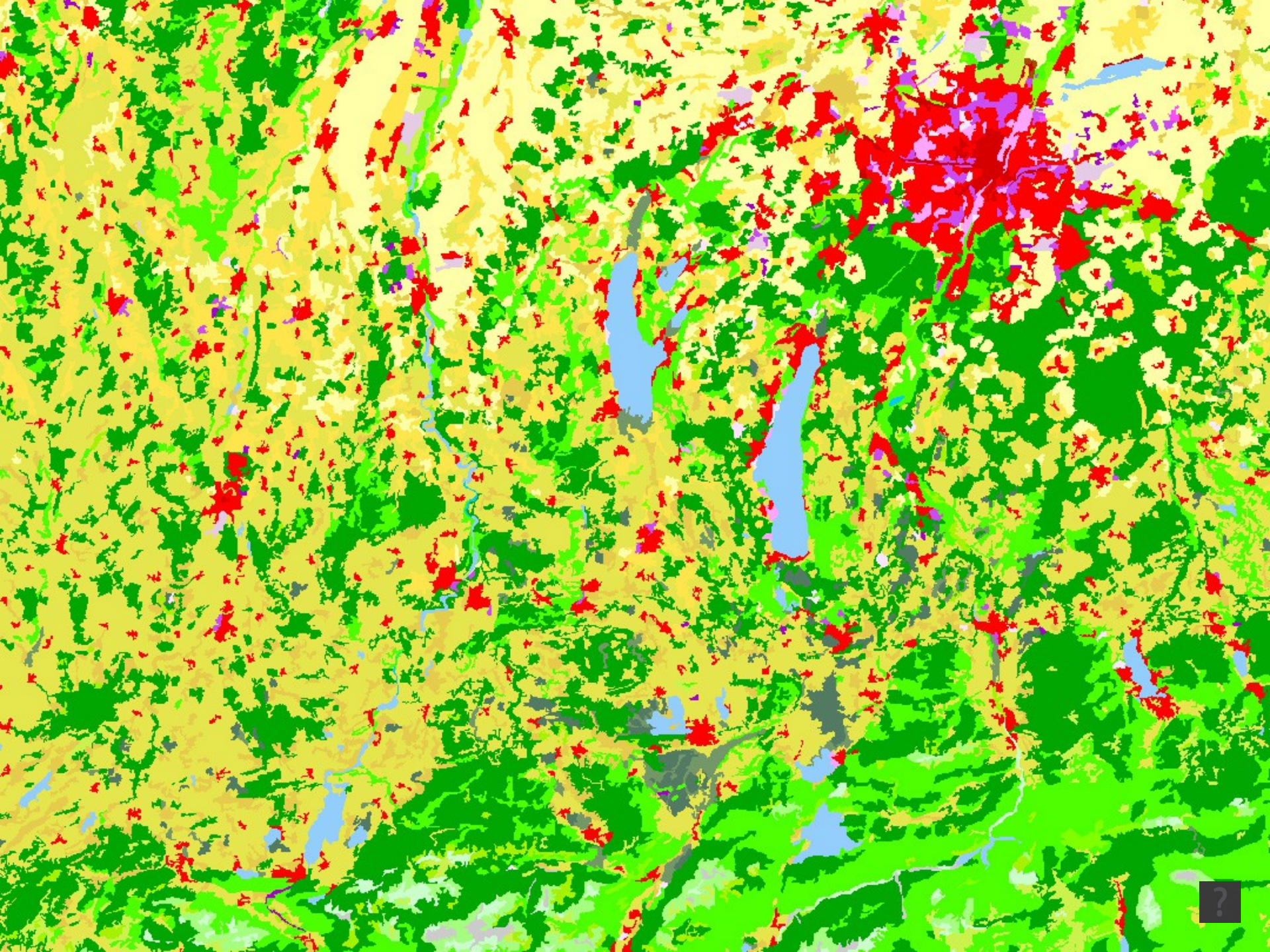
Sea level rise and salinization, coastal and delta dynamics





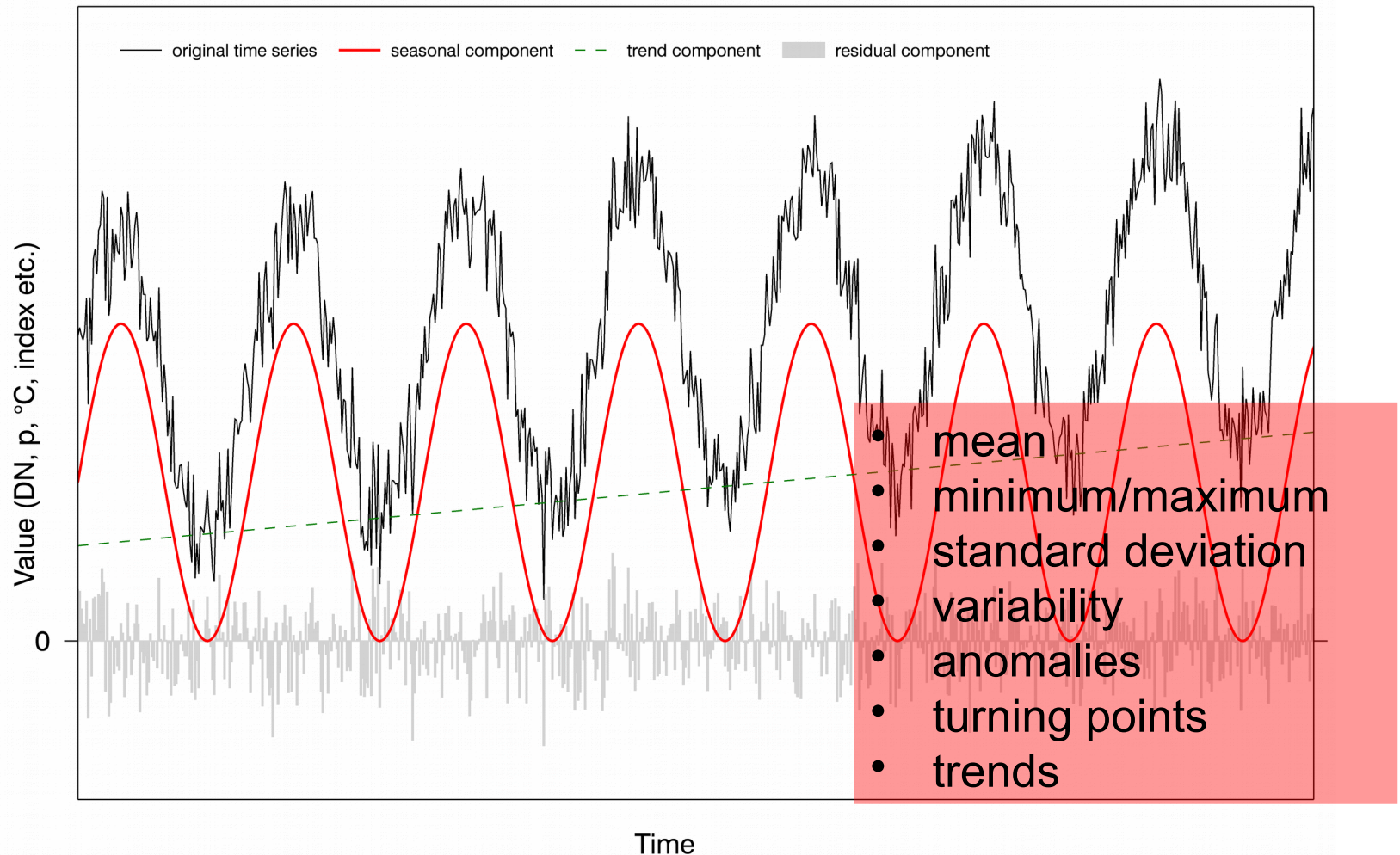
?







# Time Series Components

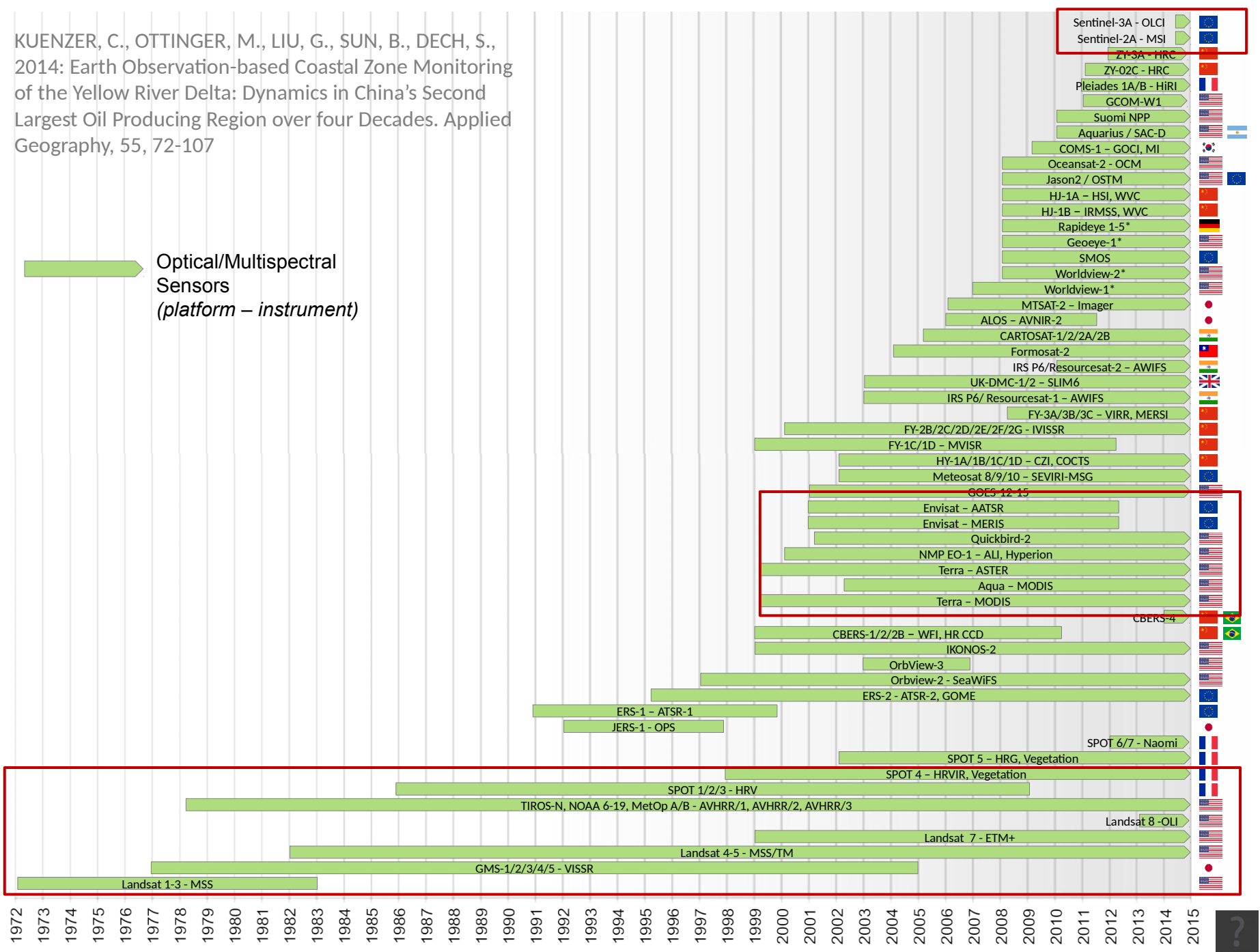


KUENZER, C., DECH, S., WAGNER, W., 2015: Remote Sensing Time Series Revealing Land Surface Dynamics: Status Quo and the Pathway Ahead. In: Kuenzer, C., Dech, S., Wagner, W. (eds.), 2015: Remote Sensing Time Series Analyses revealing Land Surface Dynamics. In print. Springer, The Netherlands



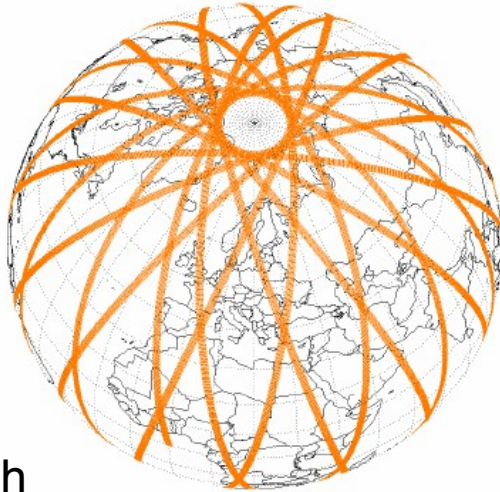
KUENZER, C., OTTINGER, M., LIU, G., SUN, B., DECH, S.,  
 2014: Earth Observation-based Coastal Zone Monitoring  
 of the Yellow River Delta: Dynamics in China's Second  
 Largest Oil Producing Region over four Decades. Applied  
 Geography, 55, 72-107

Optical/Multispectral  
 Sensors  
 (platform – instrument)

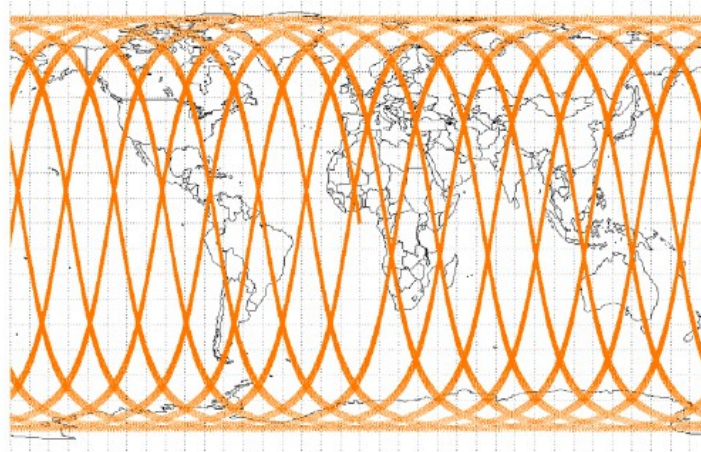




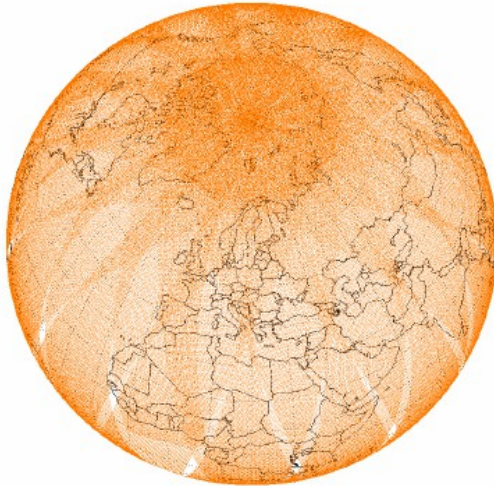
# Trade-Off between Spatial and Temporal Resolution



Daily  
swath  
coverage



Landsat 7 ETM+  
16 day repeat  
rate



MODIS  
daily repeat rate







**Snow cover**

© picture alliance/blickwinkel/F. Neukirchen



**Snow melt floods**

Whatusa.info



**Irrigation prediction**

seekraz.wordpress.com



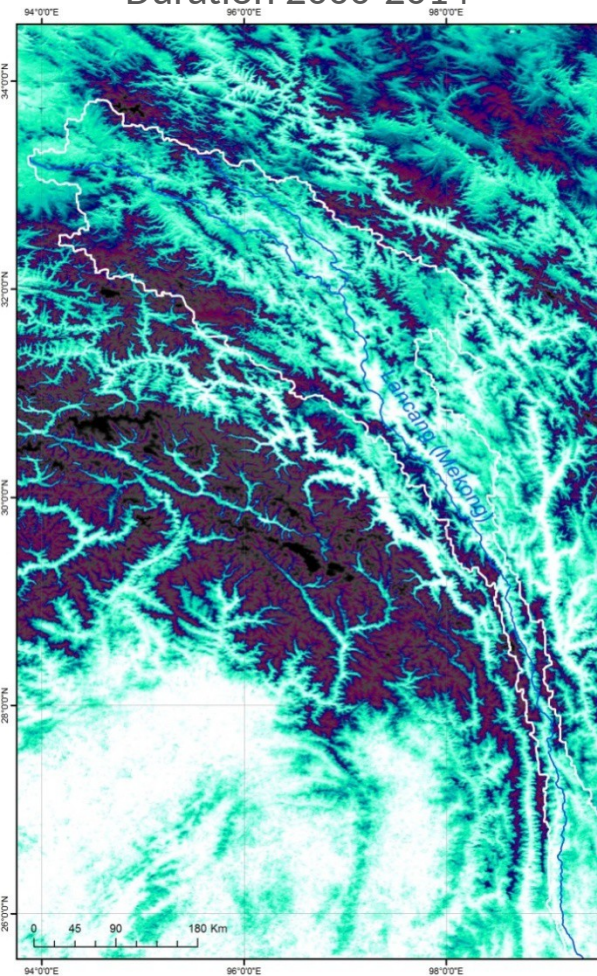
**Vegetation period**

natur-lexikon.com

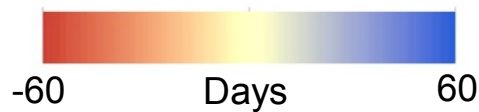
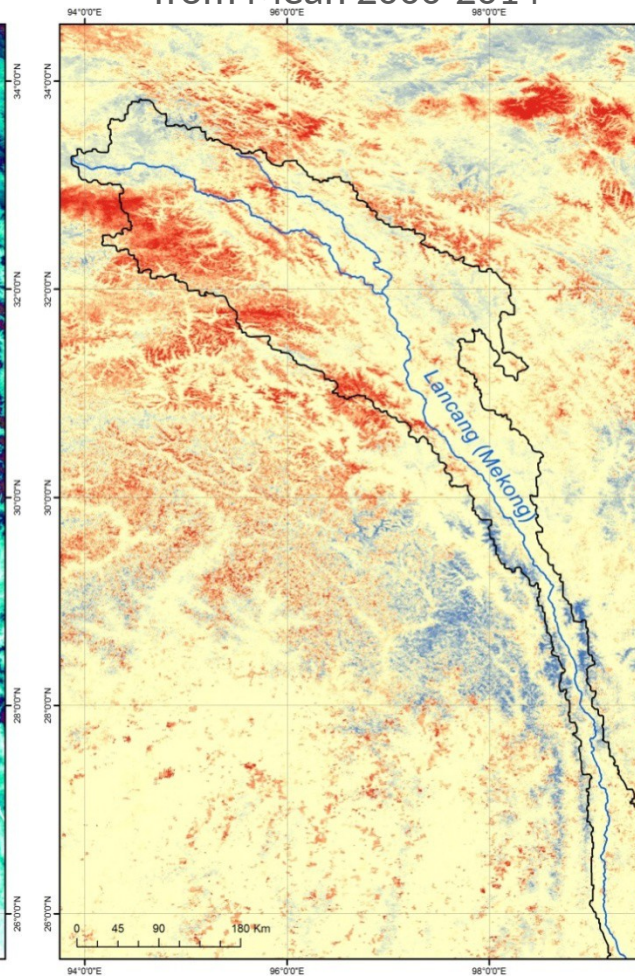


# DLR Global SnowPack

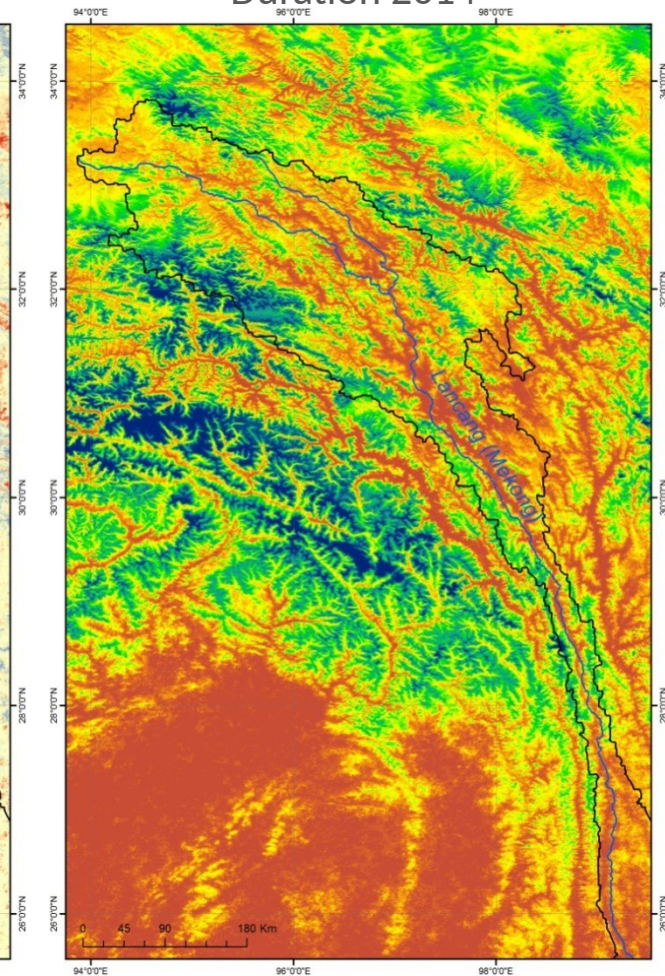
Mean Snow Cover  
Duration 2000-2014



2014 Deviation  
from Mean 2000-2014



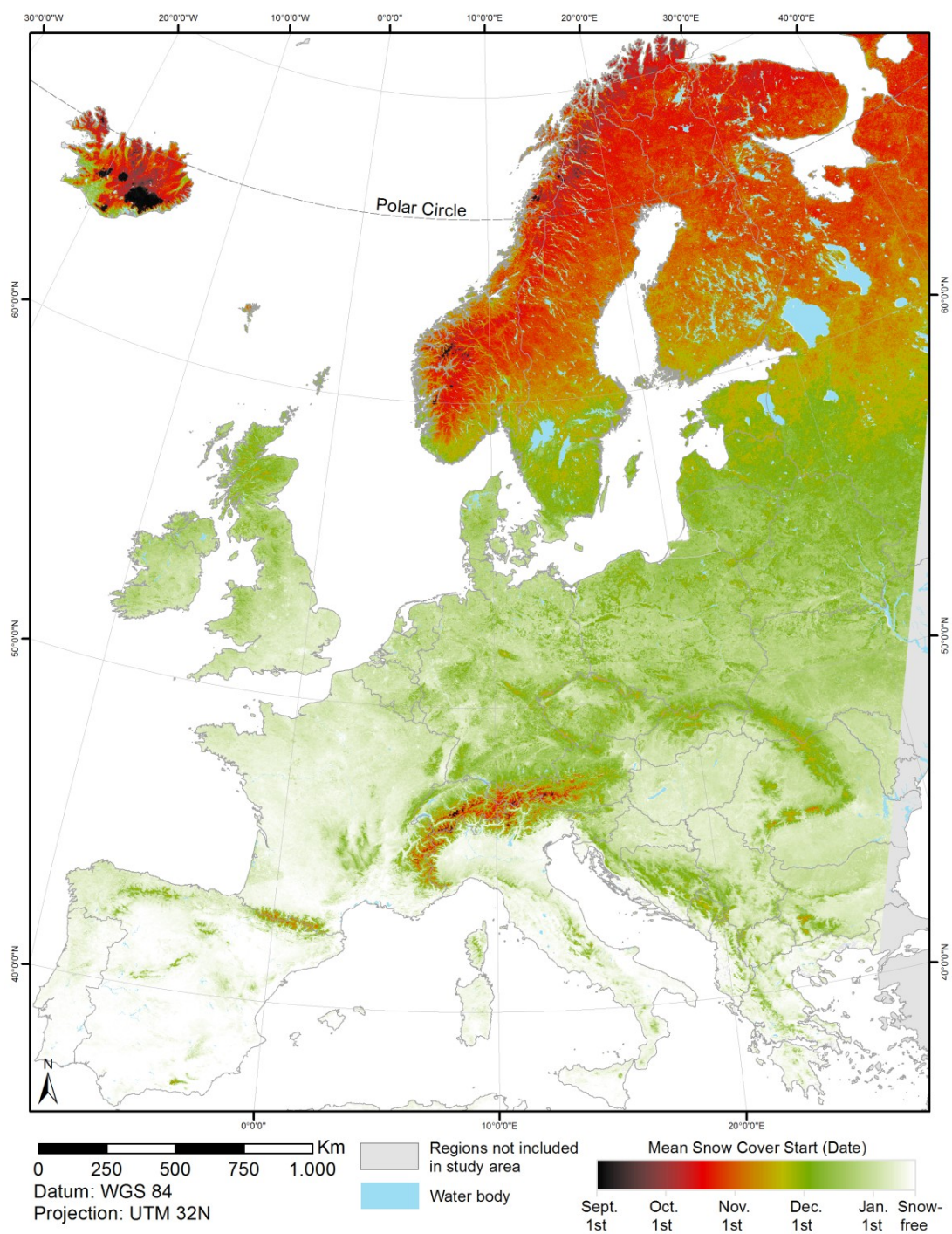
Begin of Snow Cover  
Duration 2014





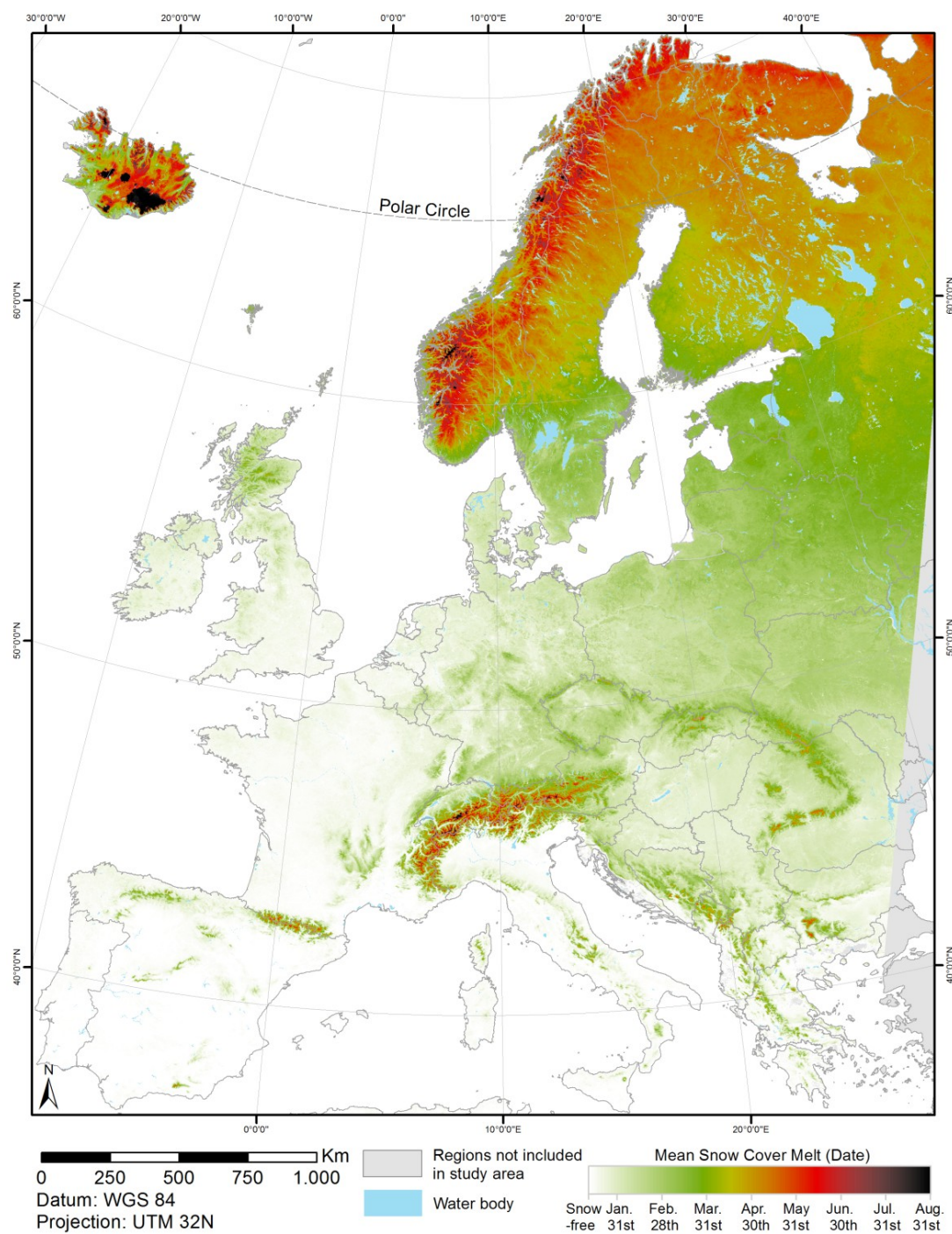
# Mean snow cover start (2000-2011)

DIETZ, A.J.; WOHNER, C.; KUENZER, C. 2012: European Snow Cover Characteristics between 2000 and 2011 Derived from Improved MODIS Daily Snow Cover Products. Remote Sens. 4, 2432-2454.



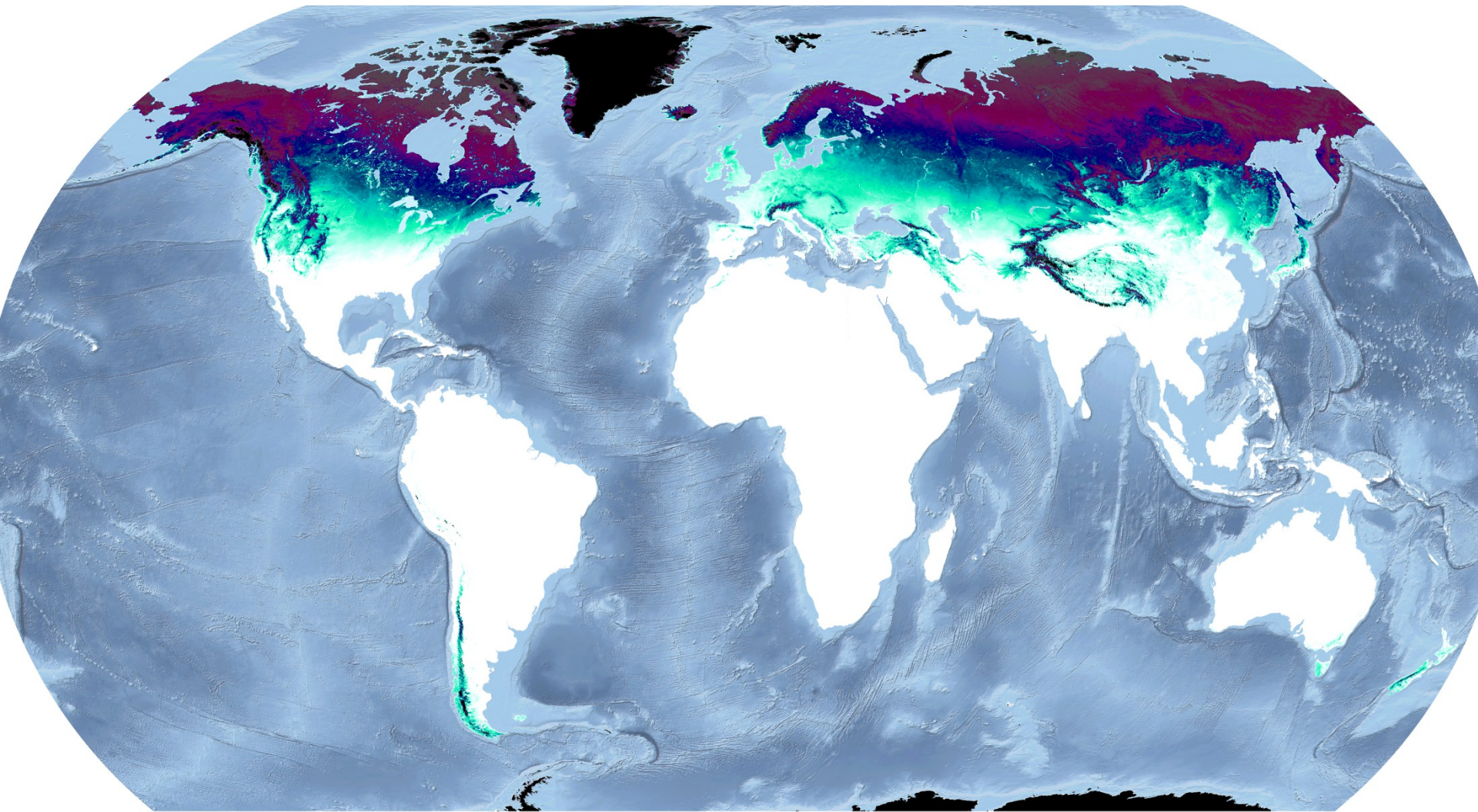


# Mean snow cover stop (2000-2011)

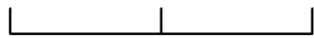




# DLR Global SnowPack



0 2.500 5.000 km



Projection: Winkel

Mean Snow Cover Duration 2000-2014

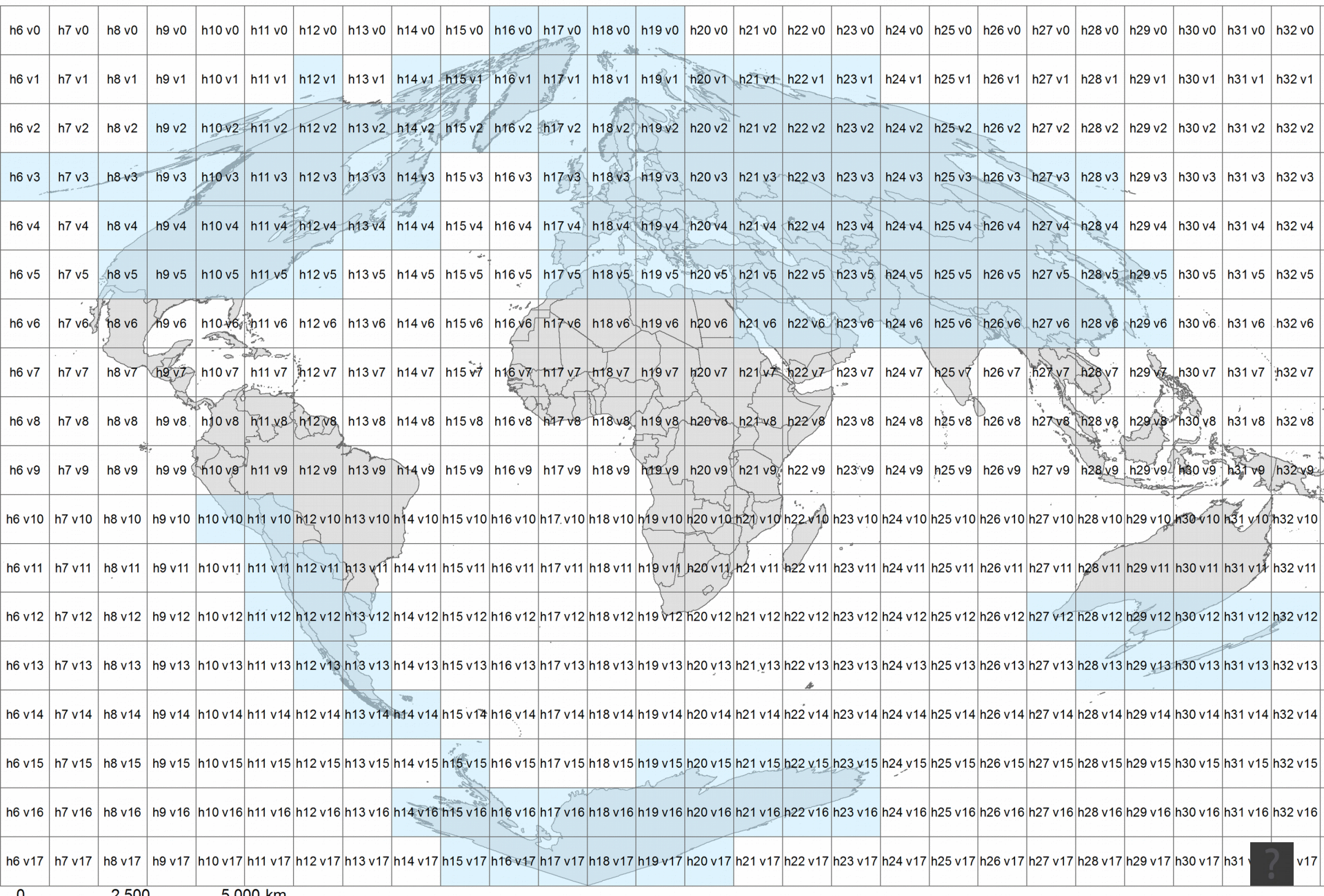


0 91 182 273 365





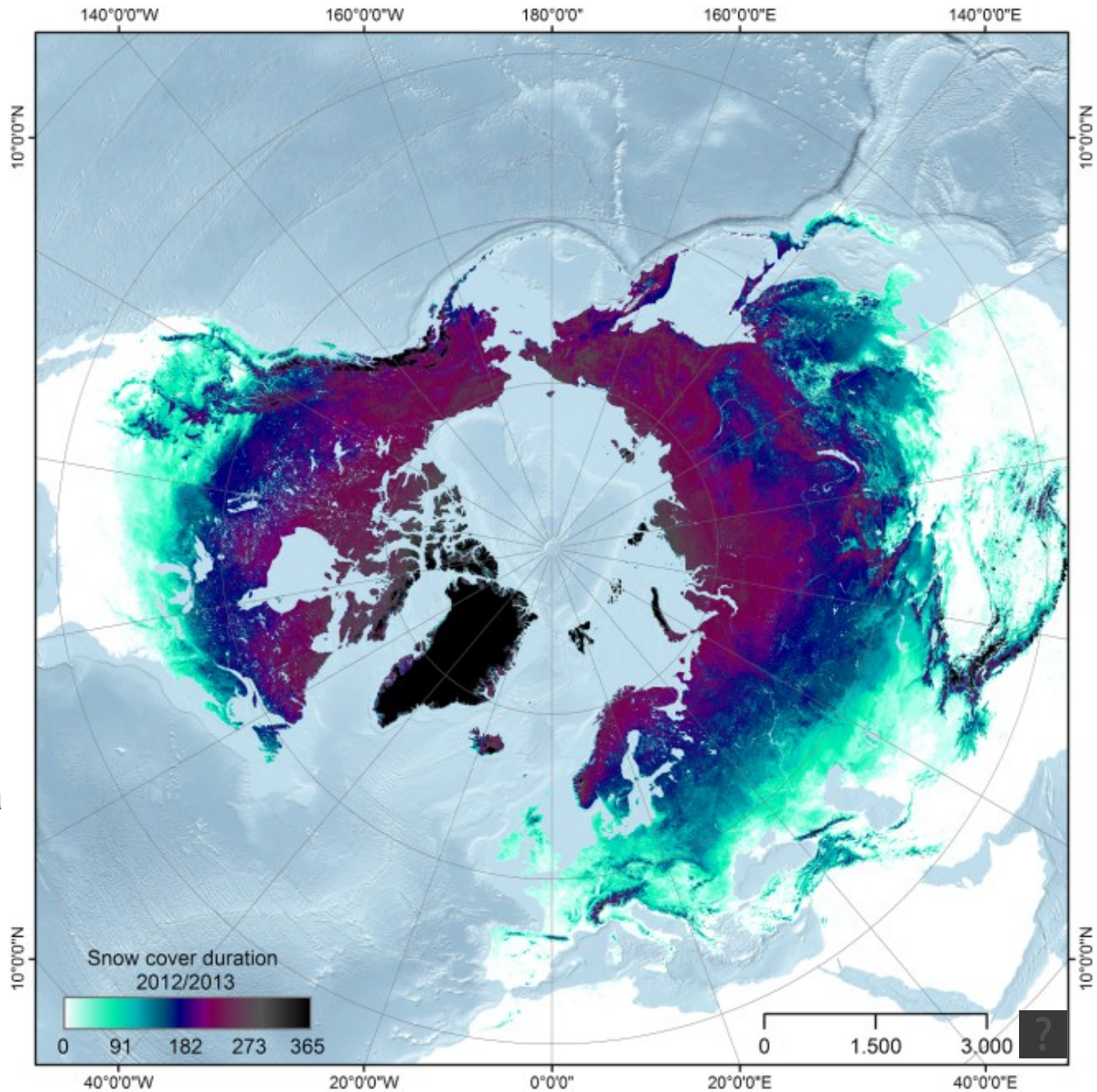
# Overview of MODIS tiles included in the Global SnowPack





## Background:

- 500m spatial resolution
- Daily snow cover information
- Products: Snow cover duration, Start and End of Snow cover season
- Consistent since 2000
- Processing of AVHRR time series under development (1km spatial resolution, daily data since ~ 1985)







**Hydropower**

[Telegraph.co.uk](http://Telegraph.co.uk)



**Water reservoirs**

[www.1000lonelyplaces.com](http://www.1000lonelyplaces.com)



**Floods**

[English.cntv.cn](http://English.cntv.cn)



**Drought impact**

[www.guardian.com](http://www.guardian.com)

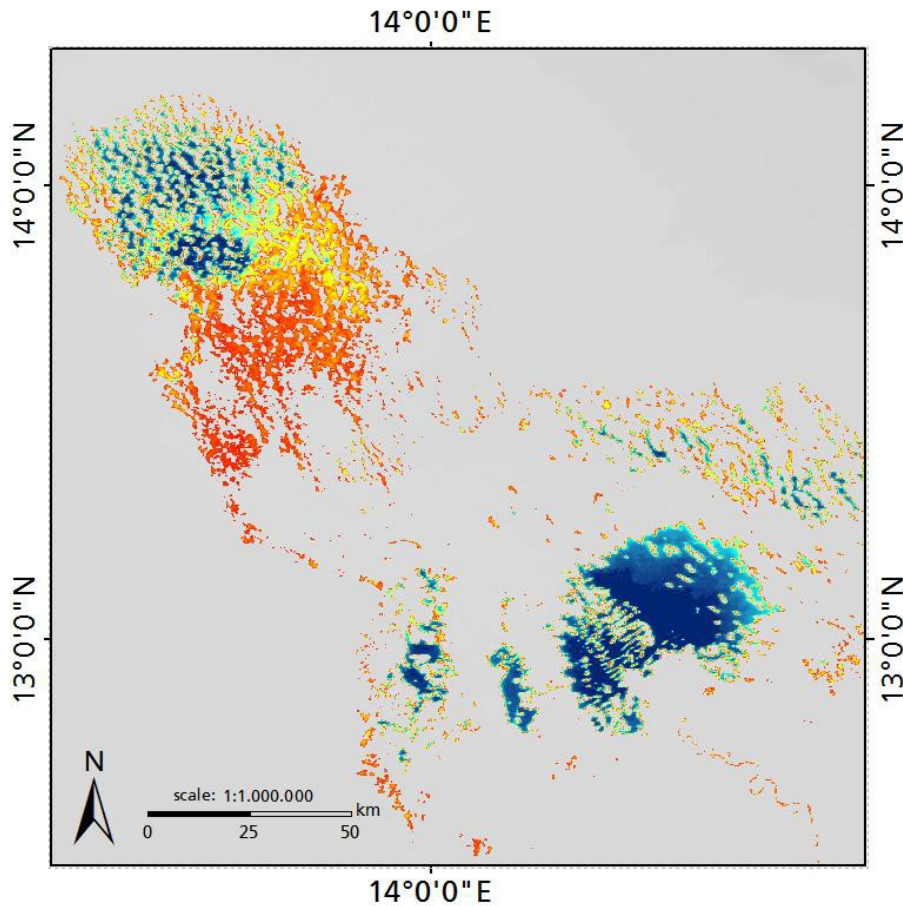




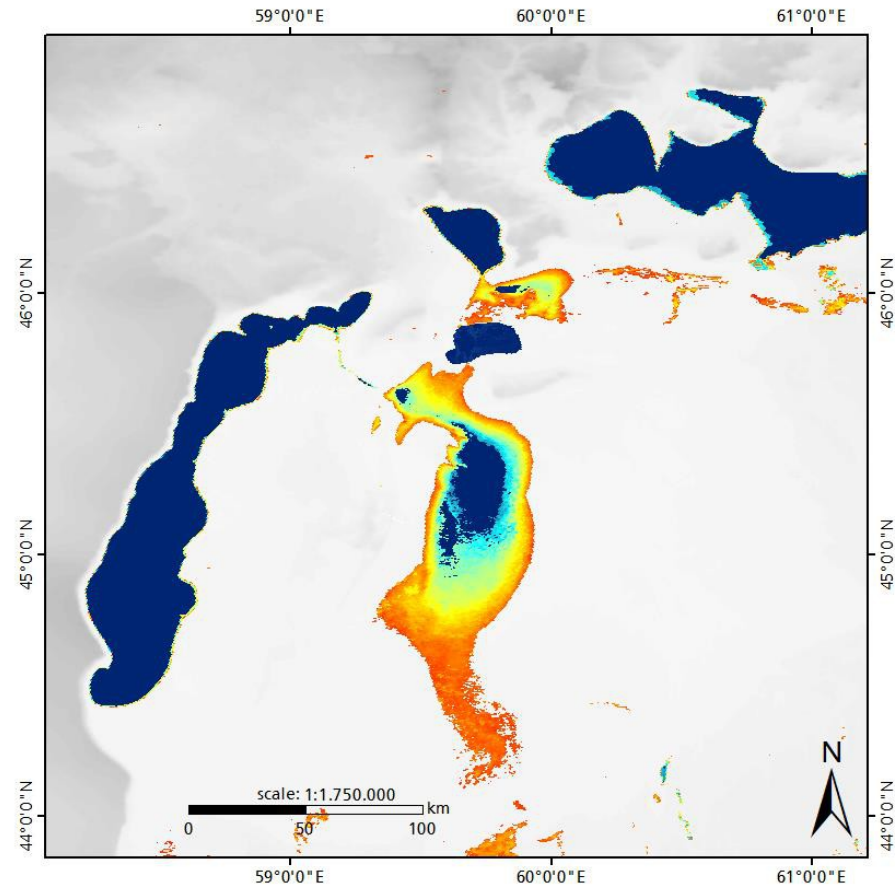
# DLR Global WaterPack

## Shrinking Lakes

### Lake Chad (Chad)



### South Aral Sea (Uzbekistan)



Water cover duration 2013 (number of days)

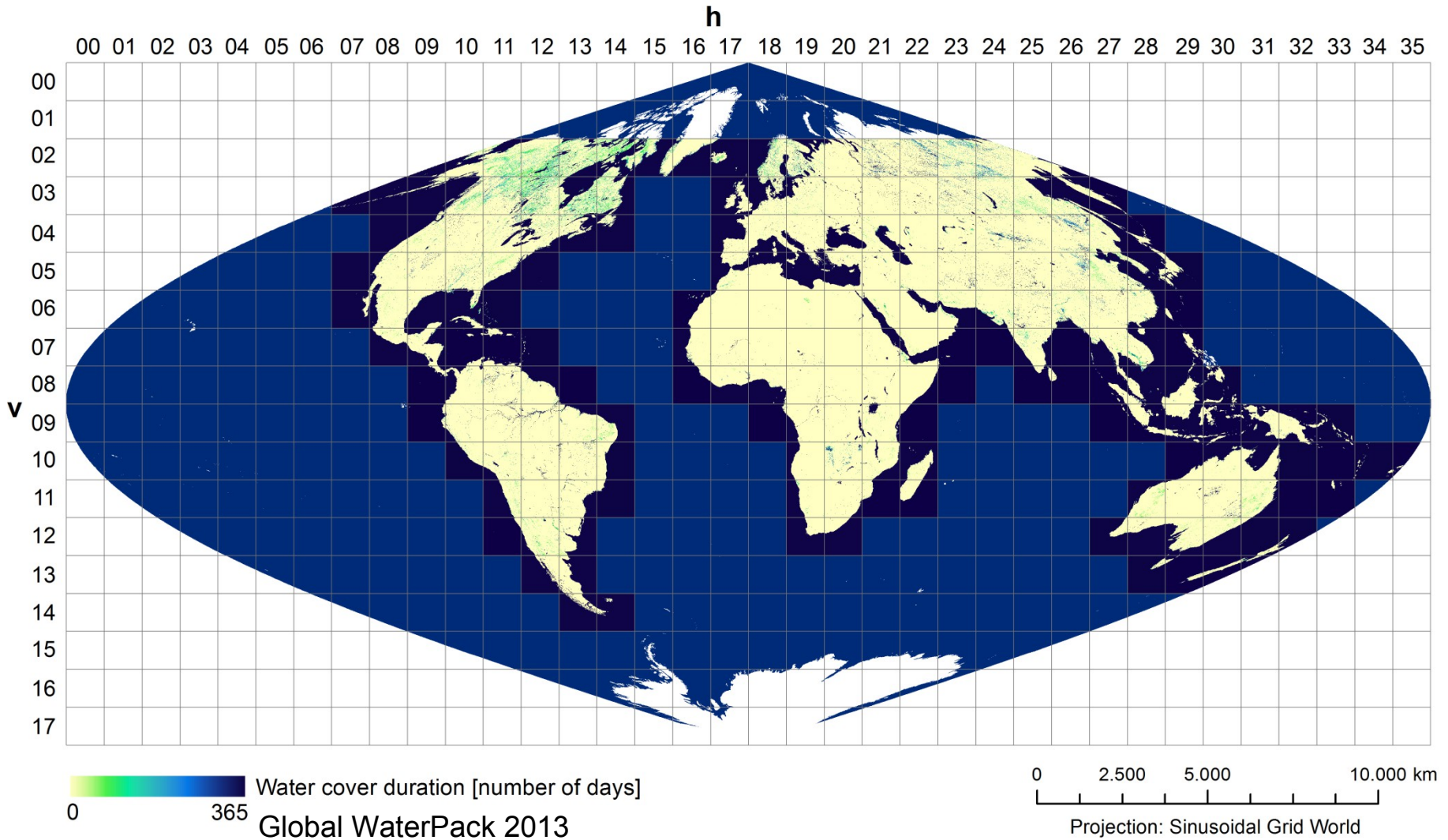


Background: DTM (m above sea level)





# DLR Global WaterPack



KLEIN, I., DIETZ, A., GESSNER, U., DECH, S., KUENZER, C. 2014: Results of the Global WaterPack: a novel product to assess inland water body dynamics on a daily basis. Remote Sensing Letters Vol. 6, Iss. 1, 2015





## SEASONAL INFORMATION

Min Extent

Max Extent

Mean

StDev

Variability

Anomalies

Trends/Tendencies

## LONG TERM ANALYSES

## ANNUAL INFORMATION

Start of inundation

End of inundation

Water cover duration

**Global WaterPack: A data set revealing information on inland water surface extent – based on medium resolution remote sensing data**

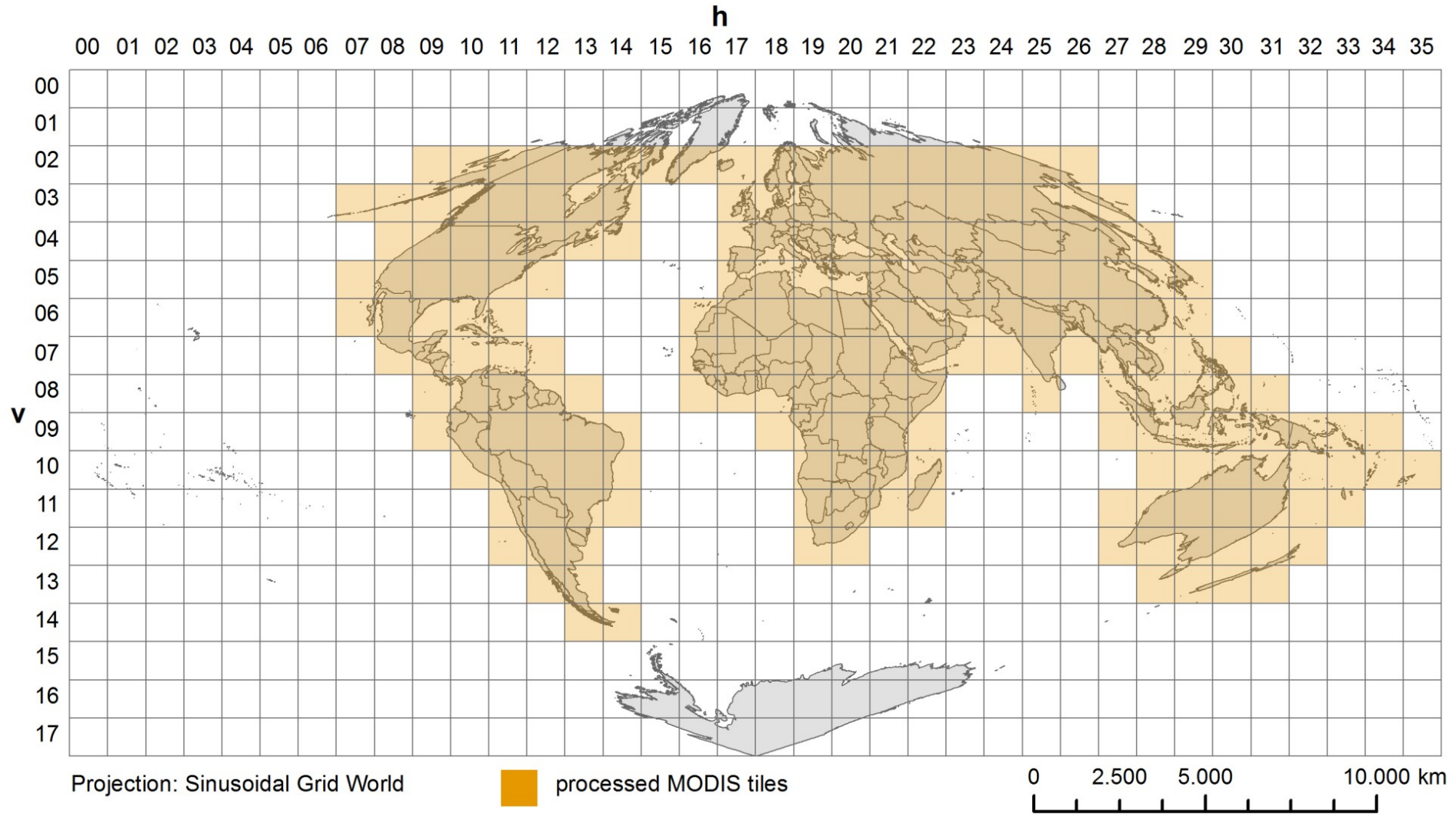
GOAL1: Supply a data set that mirrors surface inland water body information on a global scale with high (daily) temporal resolution

GOAL 2 : Answer pressing geoscientific questions in the context of water body/inundation/flood dynamics





# Overview of MODIS tiles included in the Global WaterPack



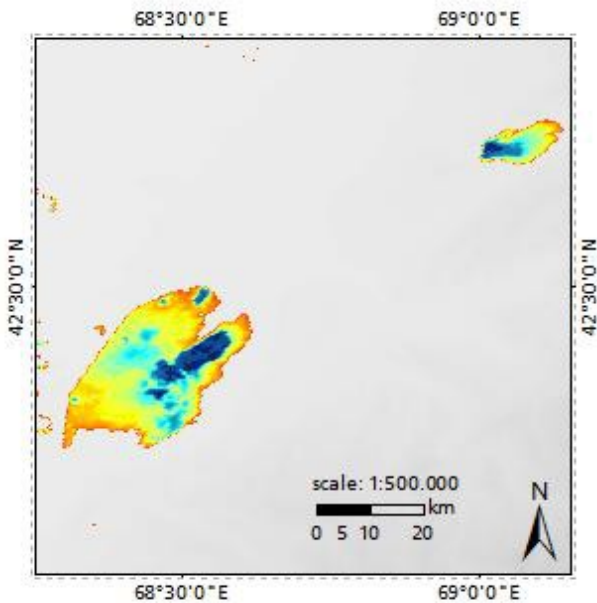
Processed Data for 2013



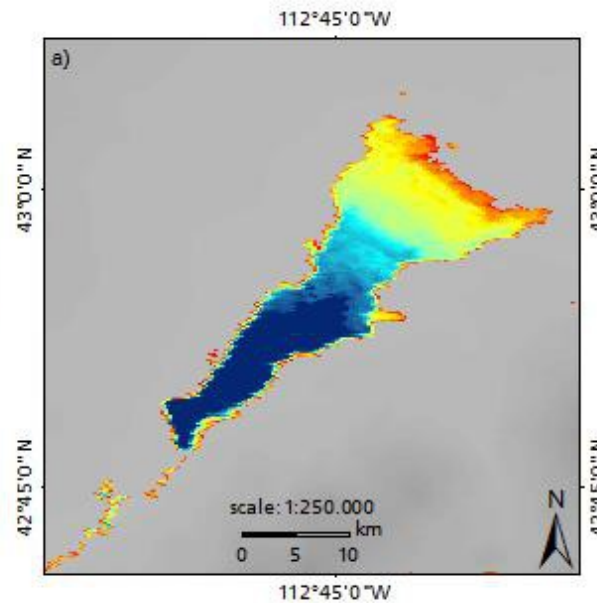


# Hydropower dams and water reservoirs

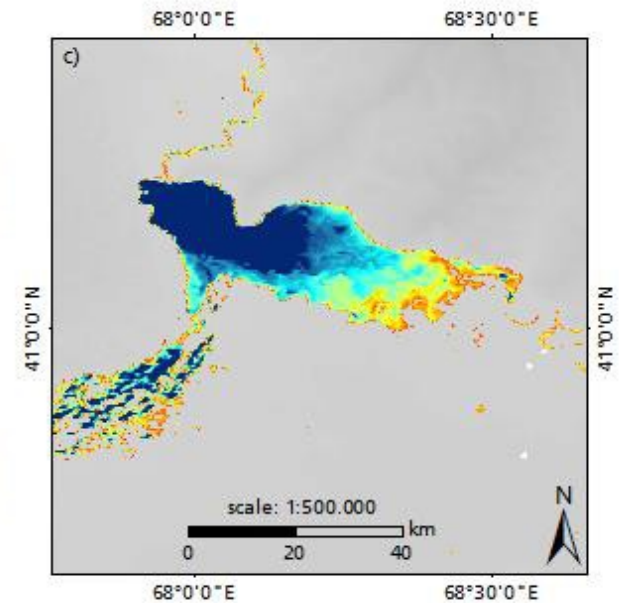
## Koksaray Reservoir



## American Falls Reservoir



## Shardara Reservoir



Water cover duration 2013 (number of days)



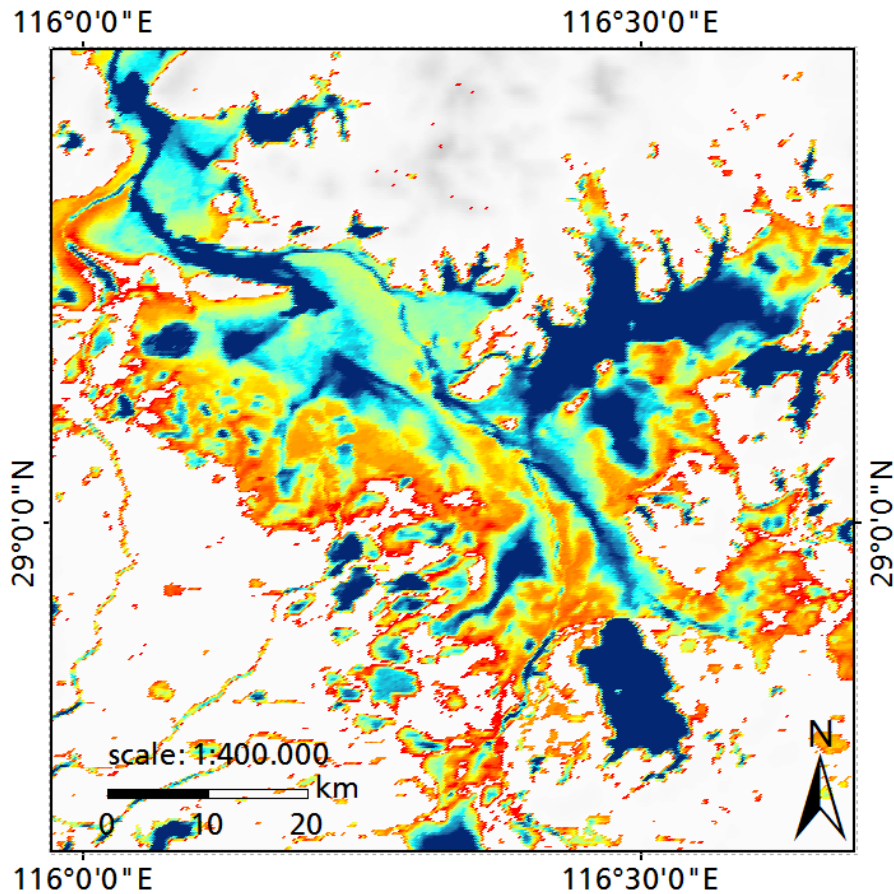
Background: DTM (m above sea level)



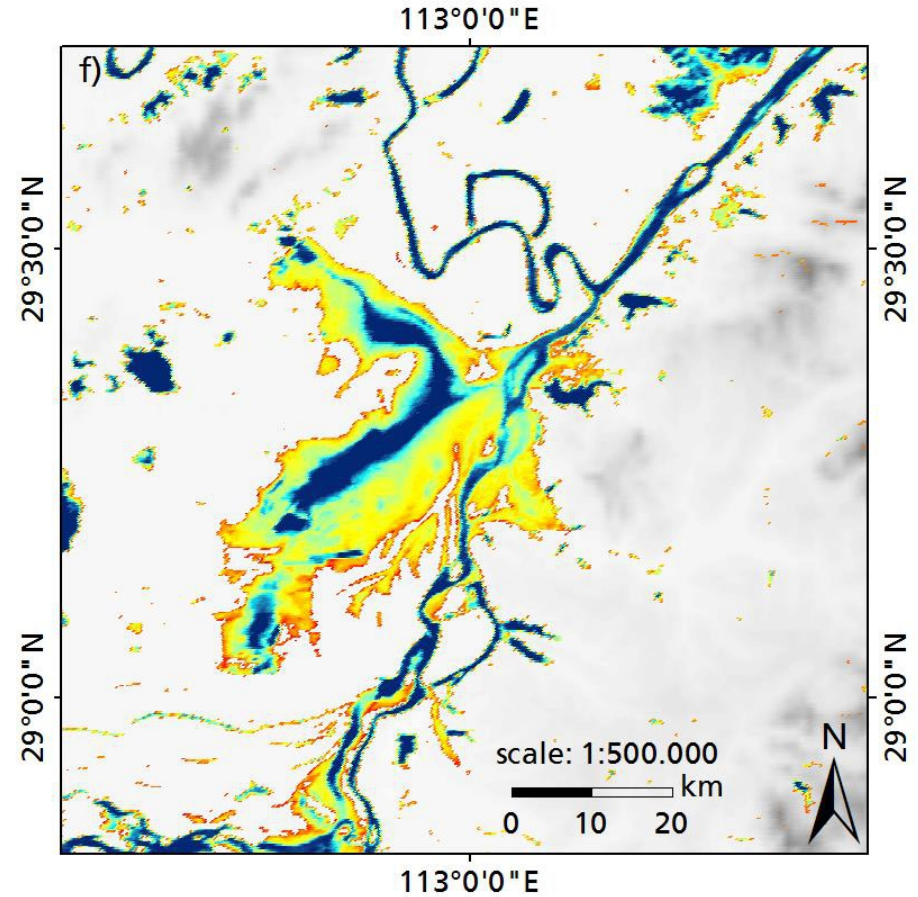


# High intra-annual variability

## Lake Poyang (China)



## Lake Dongting (China)



Water cover duration 2013 (number of days)



Background: DTM (m above sea level)

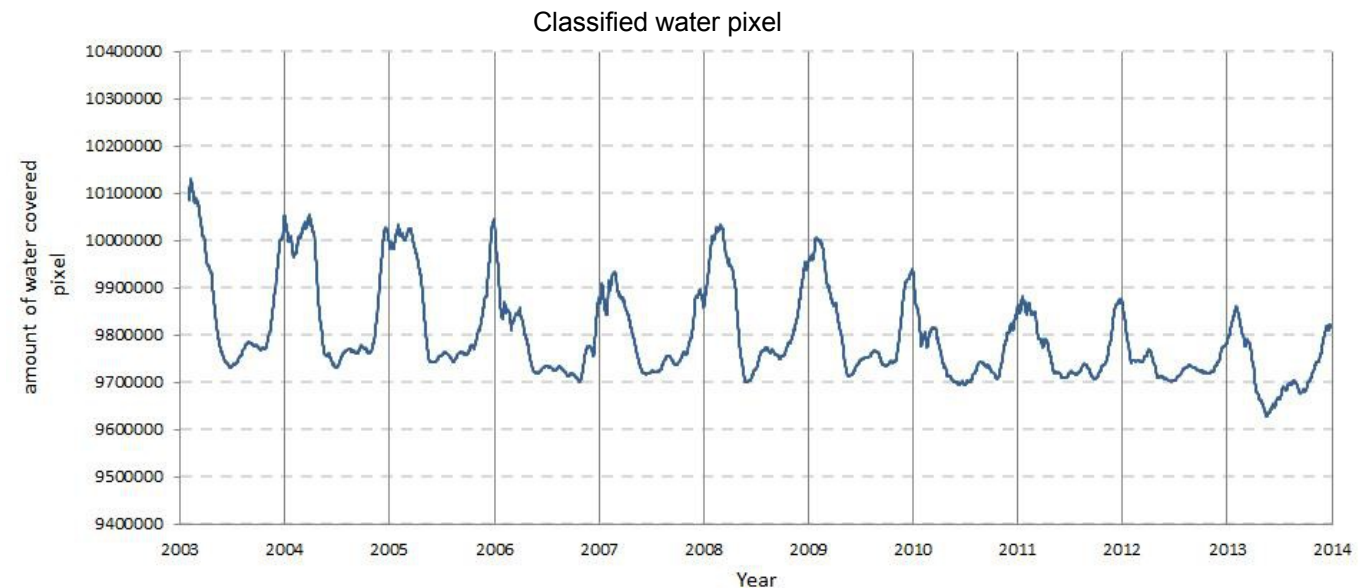




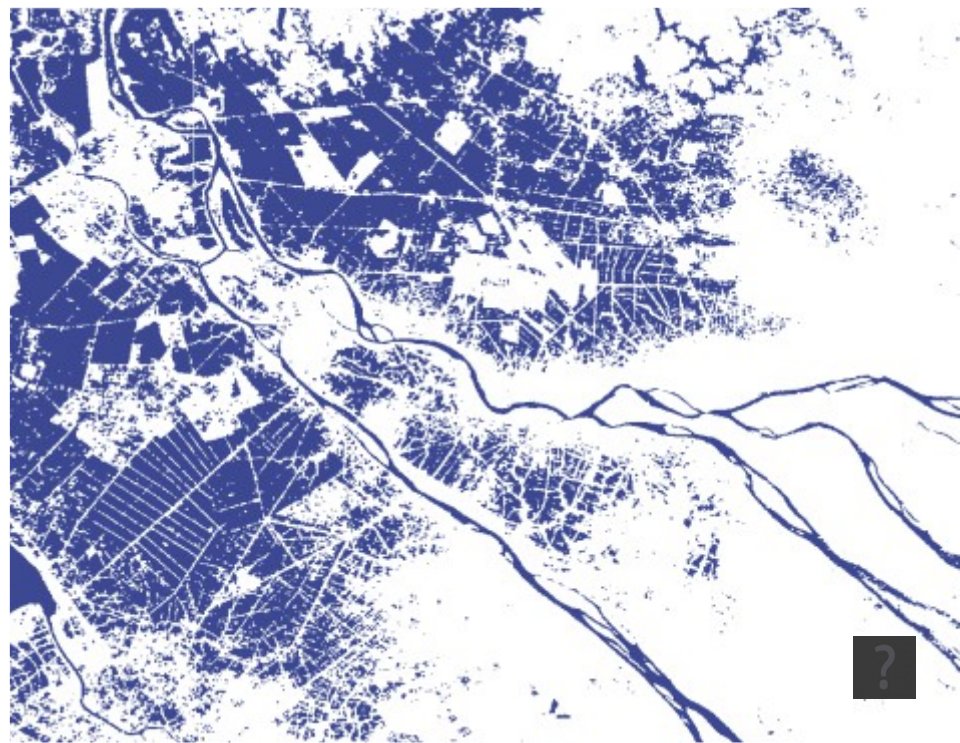
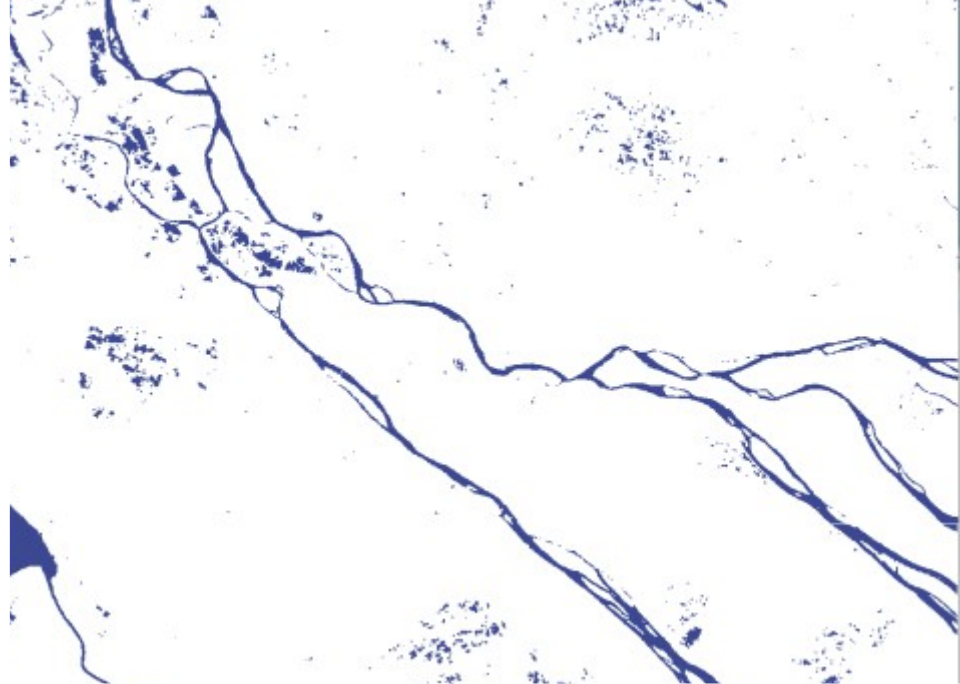
# Inter-annual dynamics: Poyang Lake, China (2003-2013)\*



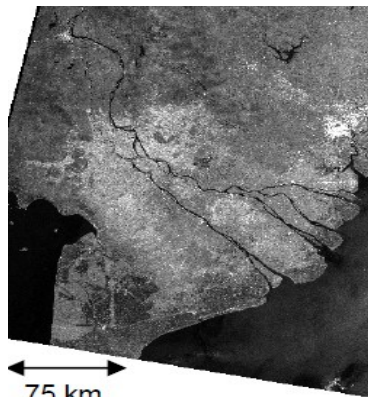
Quelle: NASA



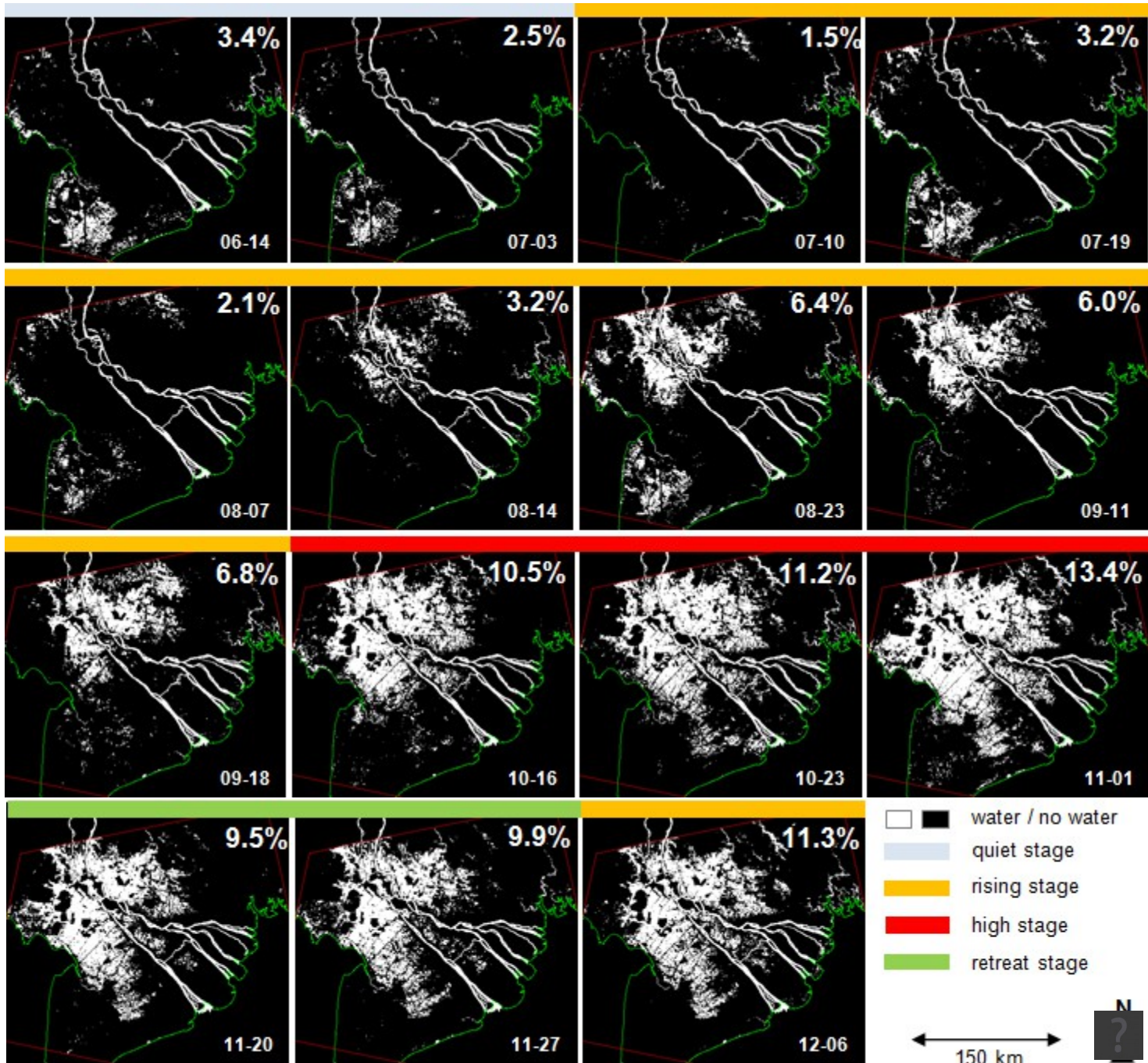






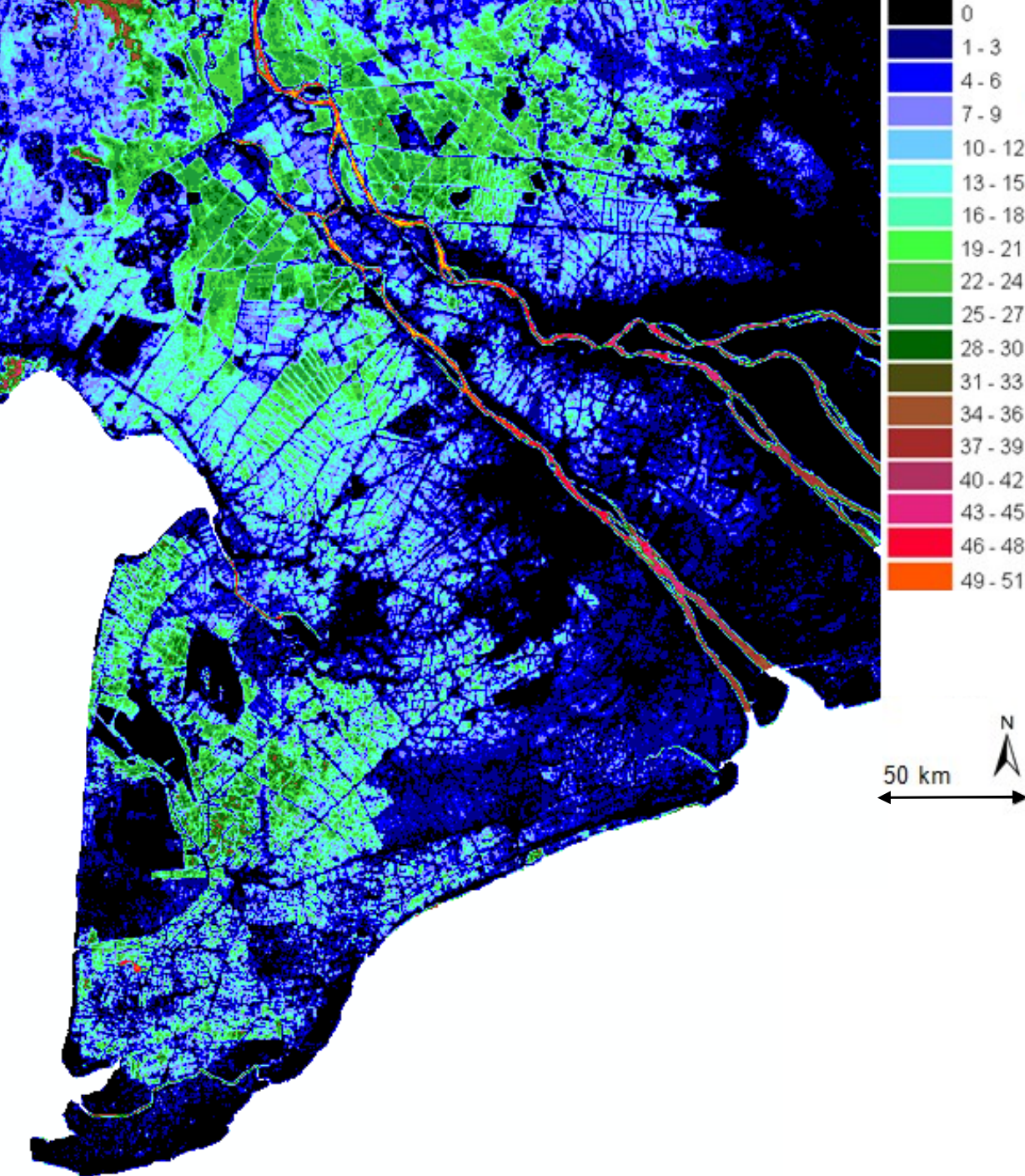


# Automatic Detection of Inundated areas



KUENZER, C., GUO, H., LEINENKUGEL, L, HUTH, J., LI, X., and S. DECH, 2013: Flood mapping and flood dynamics of the Mekong Delta: An ENVISAT-ASAR-WSM based Time Series Analyses, Remote Sensing 5, 687-715





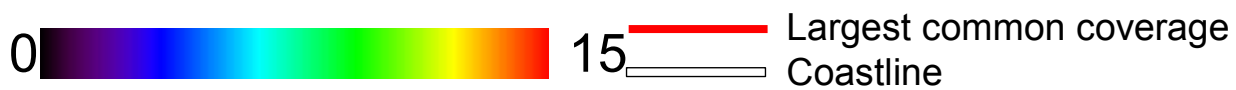
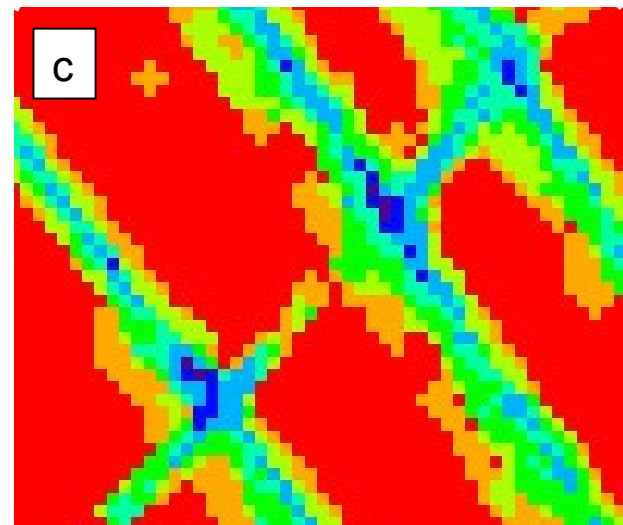
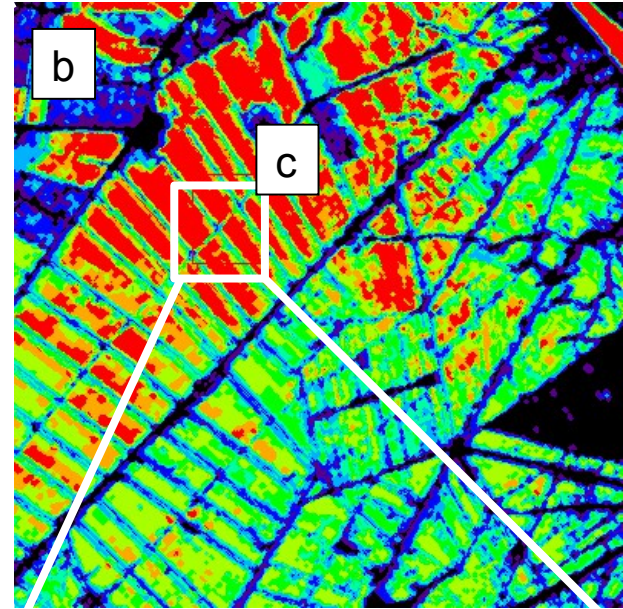
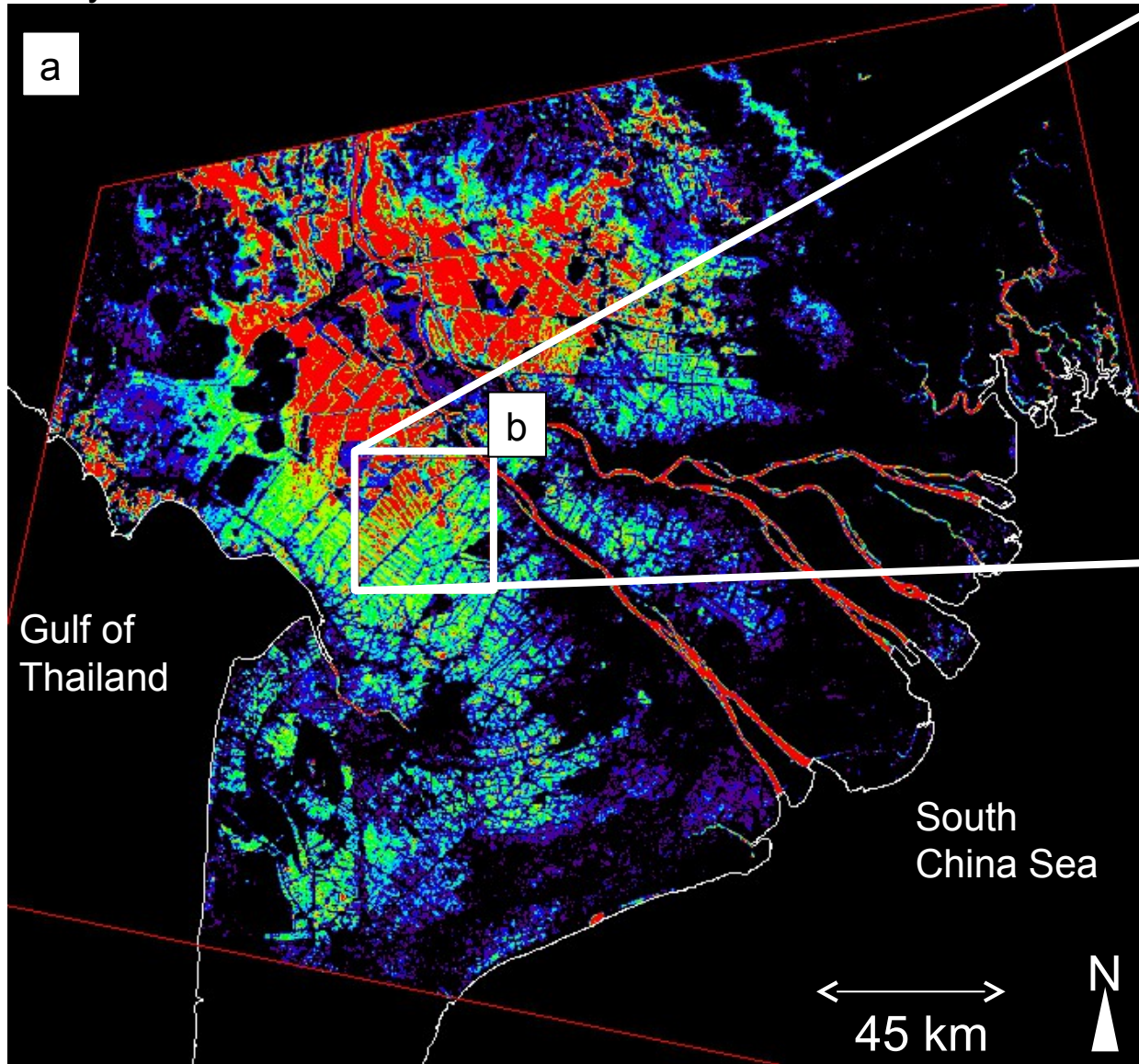
## Automatic Detection of Inundation

**Observation period 2007-2011:**  
**51 acquisitions**  
10 acquisitions per year during the rainy season, ASAR, 150m

KUENZER, C., GUO, H., LEINENKUGEL, L, HUTH, J., LI, X., and S. DECH, 2013: Flood mapping and flood dynamics of the Mekong Delta: An ENVISAT-ASAR-WSM based Time Series Analyses, Remote Sensing 5 (doi:10.3390/rs5020687), 687-715



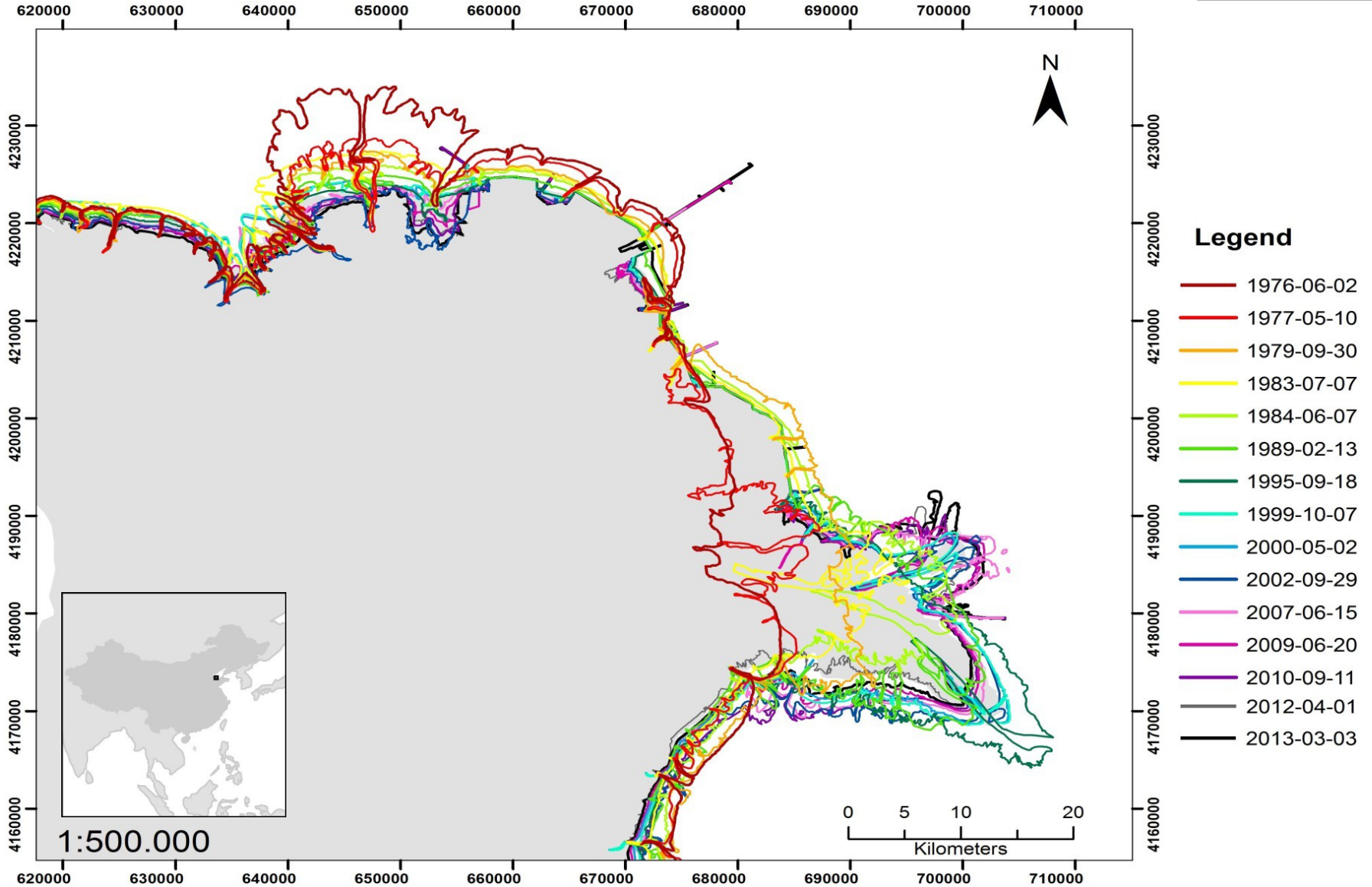
Rainy Season 2007





# Exploiting 30 Year of Satellite Data Time Series

1976 - 2013





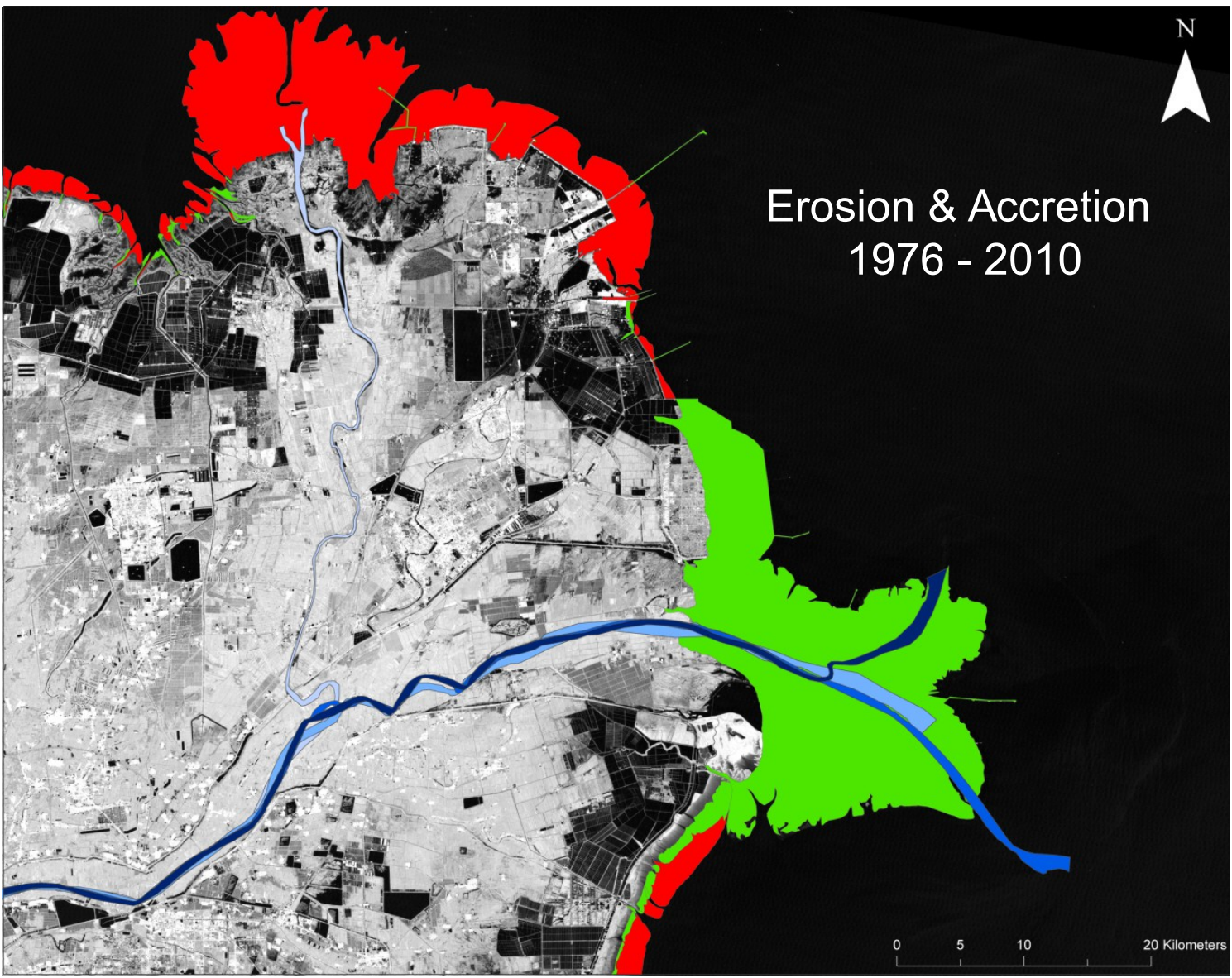
# Coastline Changes of the Yellow River Delta

1976 - 2010

## Legend

- Erosion
- Accretion

- Yellow River Course 1976
- Yellow River Course 1984
- Yellow River Course 1995
- Yellow River Course 2010







**Irrigation**

CC license, Flickr, 2014



**Deforestation**

CC license, Flickr, 2014



**Cash crops**

CC license, Flickr, 2014

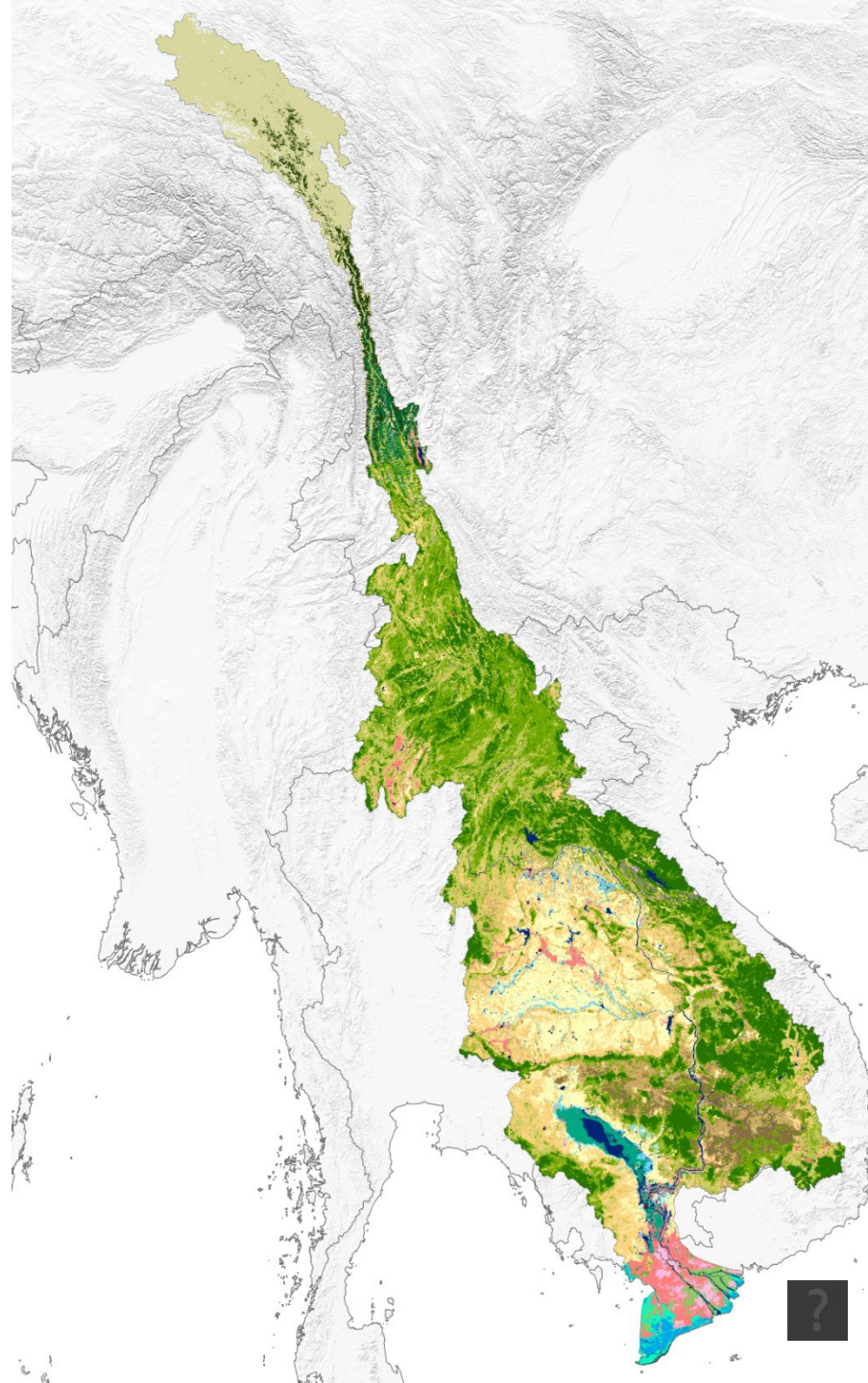
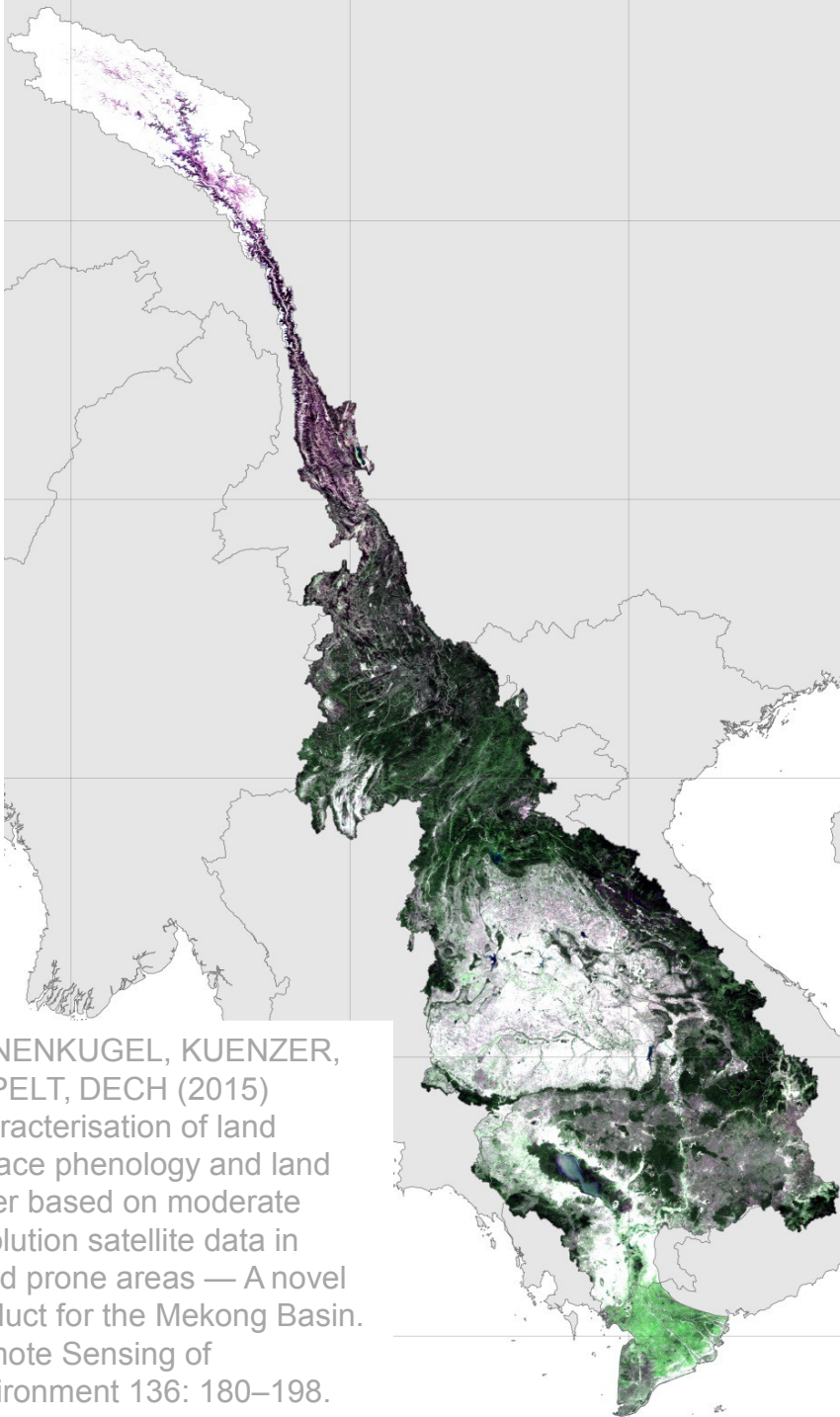


**Mining**

www.laosgpsmap.com



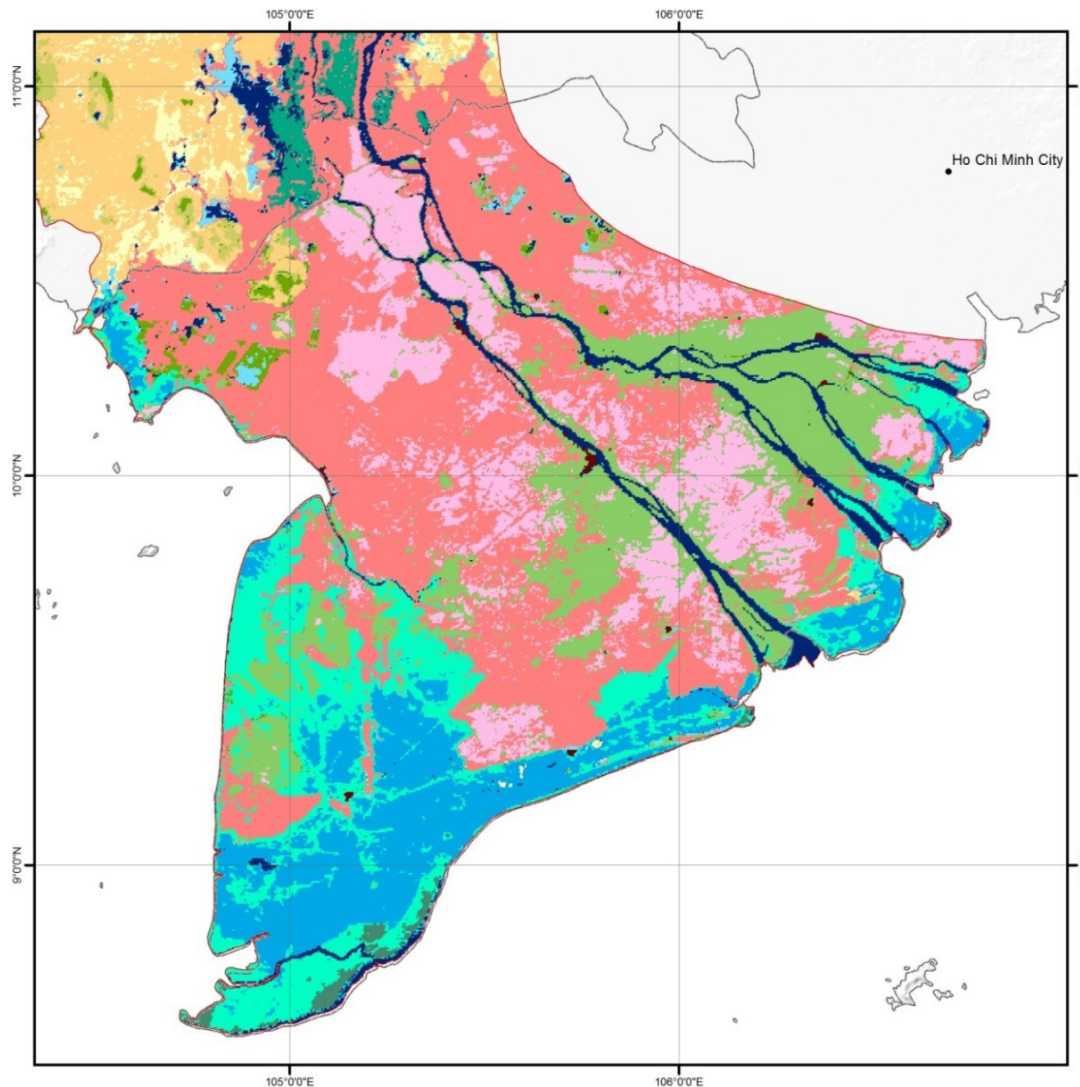





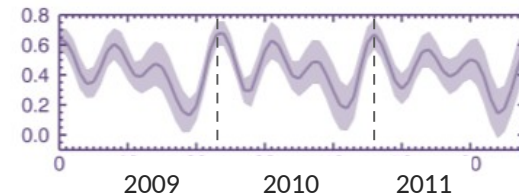
LEINENKUGEL, KUENZER,  
OPPELT, DECH (2015)  
Characterisation of land  
surface phenology and land  
cover based on moderate  
resolution satellite data in  
cloud prone areas — A novel  
product for the Mekong Basin.  
Remote Sensing of  
Environment 136: 180–198.




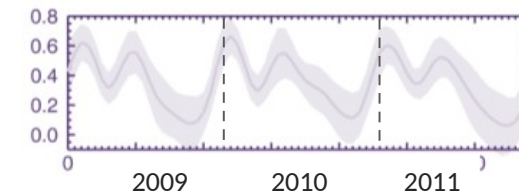
# Cropland classification in the Mekong Delta




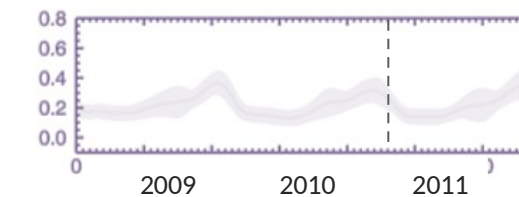
 Rice paddy harvested  
3 times per year



 Rice paddy harvested  
2 times per year

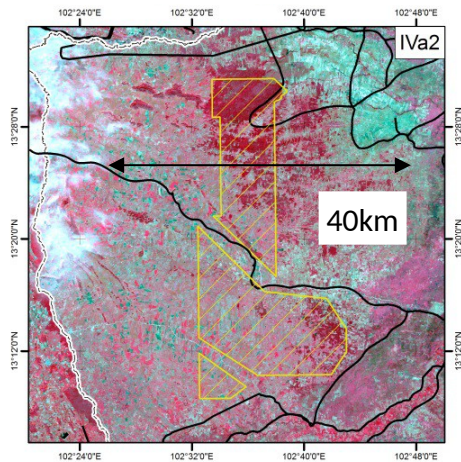
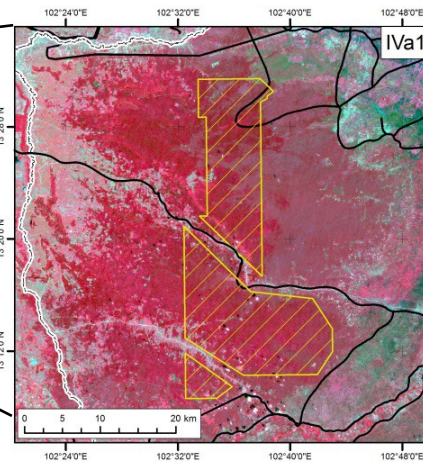
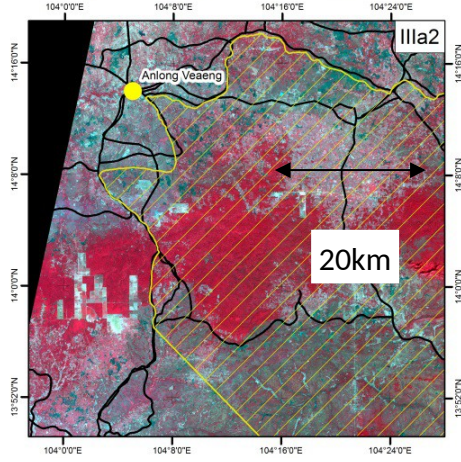
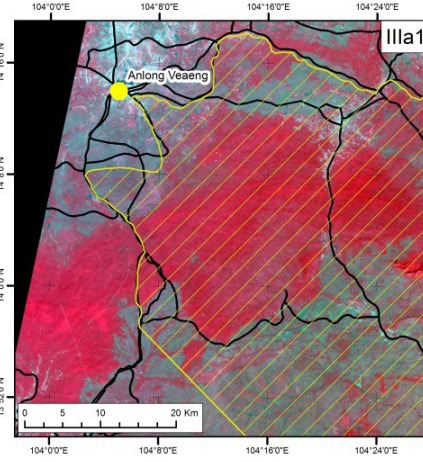
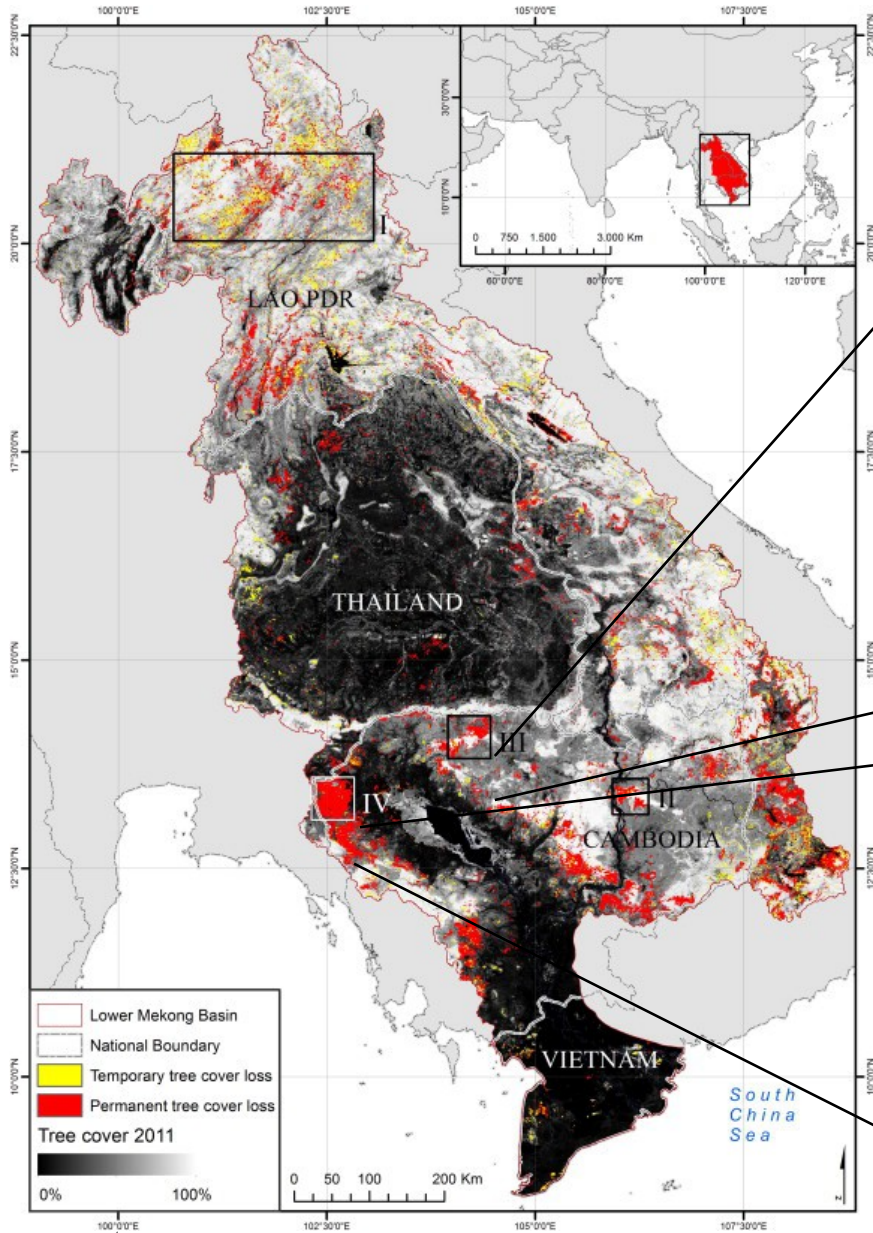


 Rice paddy harvested  
one time per year





# Tree cover dynamics 2001-2011



Satellite data  
 IIIa1: LS ETM+ 2000; IIIa2: LS TM 2010  
 IIIa1: ASTER 2002; IIIa2: ASTER 2011  
 IVa1: LS ETM+ 2001; IVa2: LS TM 2009

National border  
 Conservation area  
● Village/city  
 Major road

LEINENKUGEL, WOLTERS, OPPELT, KÜNZER (2015) Tree cover and forest cover dynamics in the Mekong Basin from 2001 to 2011. Remote Sensing of Environment 158: 376–392.



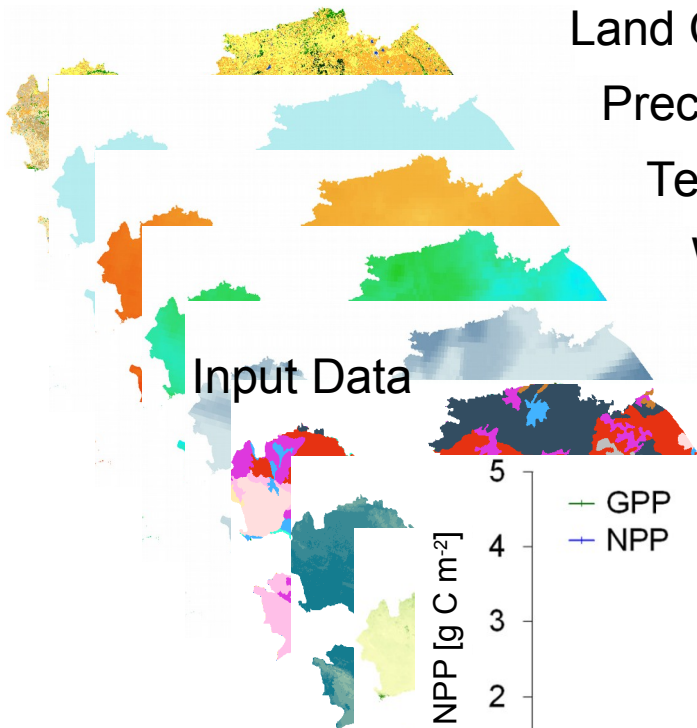




# Biomass and NPP Modeling

## BETHY/DLR

Biosphere Energy Transfer Hydrology Model  
(Knorr 1997, Wißkirchen 2005)



Land Cover, DLR (1 km)

Precipitation, ECMWF (0.25°)

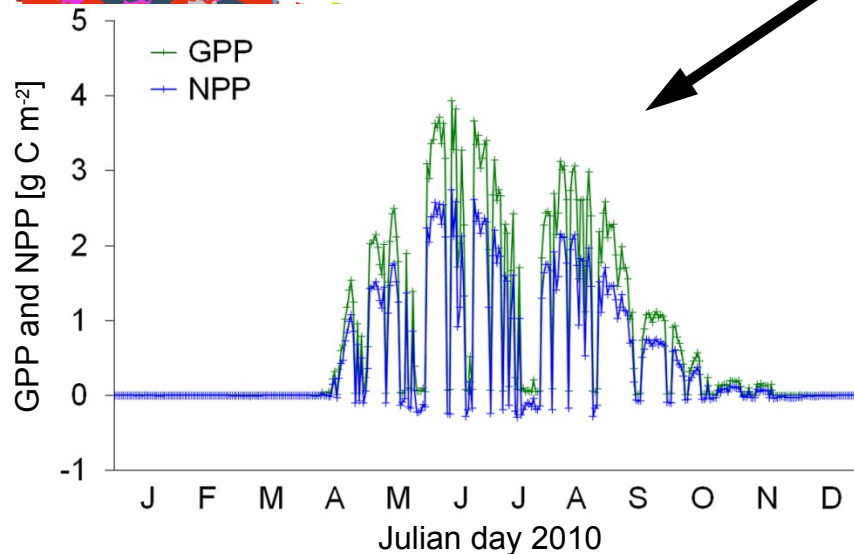
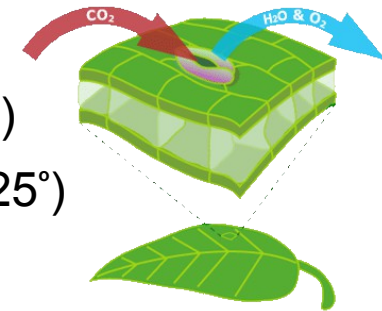
Temperature, ECMWF (0.25°)

Wind Speed, ECMWF (0.25°)

Cloud Cover, ECMWF (0.25°)

Soil types, FAO (1 km)

Photosynthetic Reactions  
(Farquhar)



University of California Museum of Paleontology's Understanding Evolution

i)

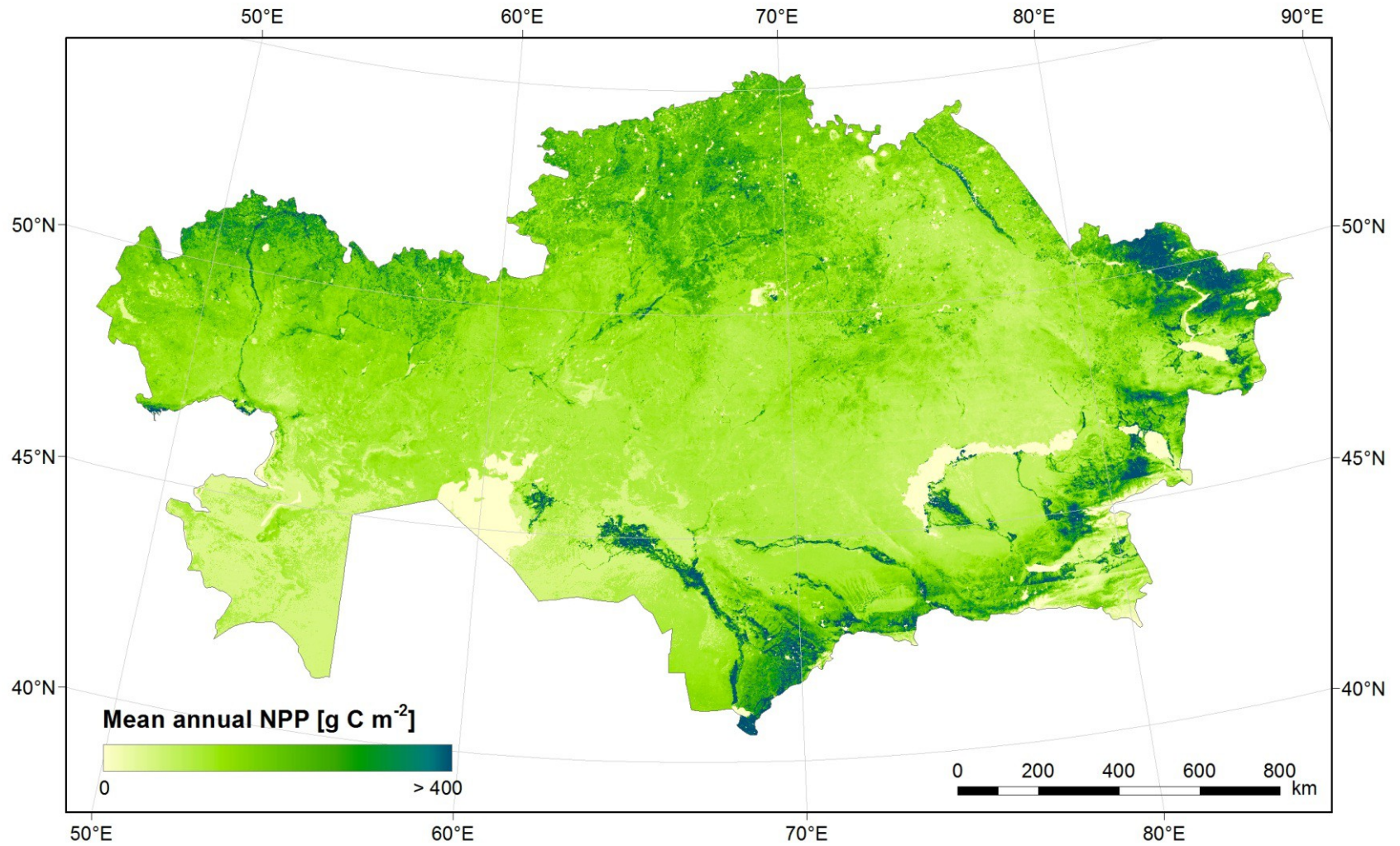
Gross- (GPP) and Net-  
Primary-Productivity  
(NPP)

Maintenance Respiration

$NPP = GPP - MR$



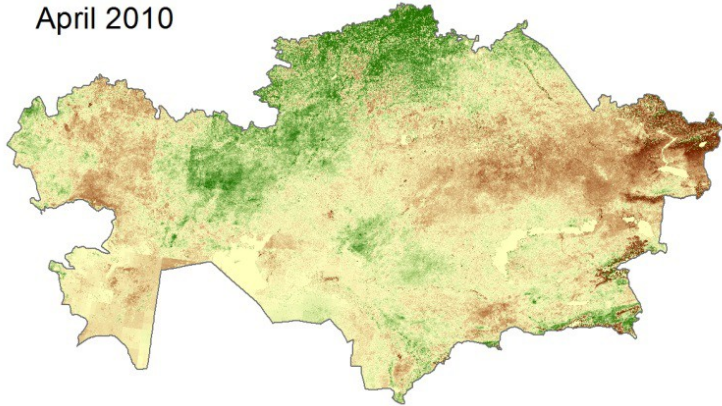
# Mean annual NPP for 2003–2011



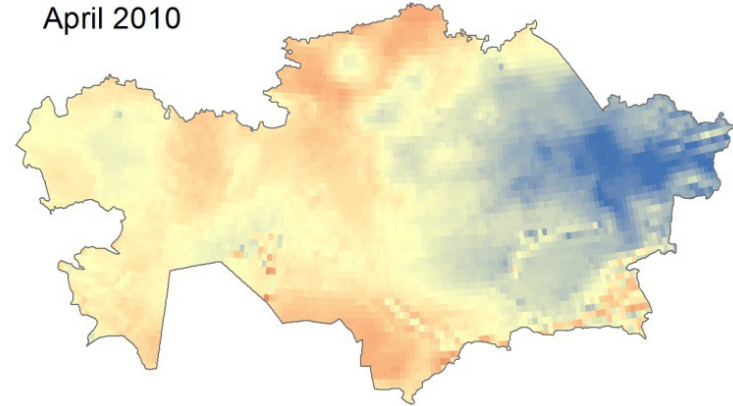


# Comparison of NPP and temperature deviations

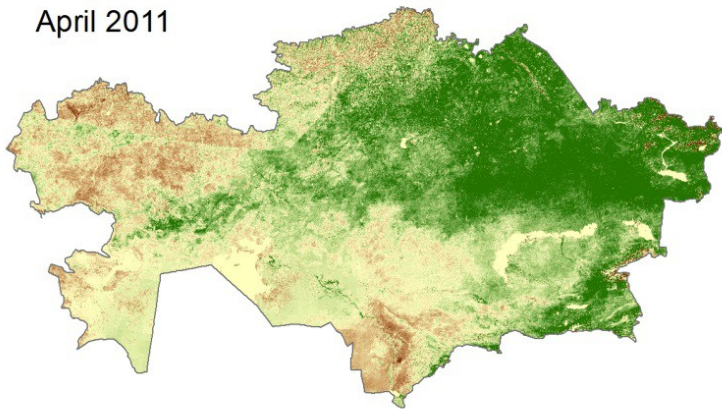
April 2010



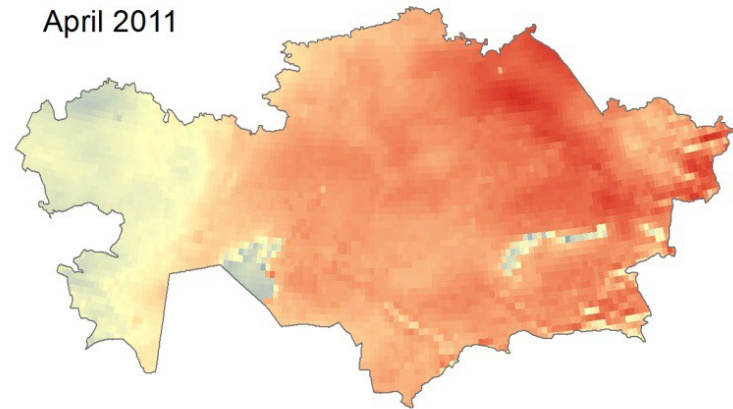
April 2010



April 2011



April 2011



Deviation from mean monthly NPP [%]



Deviation from mean monthly temperature [°C]





# BETHY/DLR – Modelled NPP in Europa and Africa





# Overview Group ,Land Surface Dynamics‘ at DLR

## Scientists and Funding

- 18 Scientists of which 6 are Post-Docs, 6 are scientists, 6 PhD students
- 90 % third party funding (BMBF, EU, AA, NERC, DAAD, UN, Worldbank, IB, IUCN)

## Geodata Analyses assessing Land Surface Dynamics

- Landcover, landuse, dynamics, and change, investigation of drivers
- Snow, floods, innundation, droughts, wetlands and coastal zone
- Forest ecosystems, forest types, Ecosystem Services
- Net primary production, biomass, crops, bioenergy, and carbon
- Products for hydrologic and climatologic modelling

## Environmental Information Systems

- User-oriented visualization and transport of results to users and stakeholders







**Team: “Land Surface Dynamics” at DLR**





Thank you for your attention!



[juliane.huth@dlr.de](mailto:juliane.huth@dlr.de) - Presenter

[claudia.kuenzer@dlr.de](mailto:claudia.kuenzer@dlr.de) - Head of Team Land Surface Dynamics at  
DLR