Sentinel-2
Chancen für die Global Change Forschung

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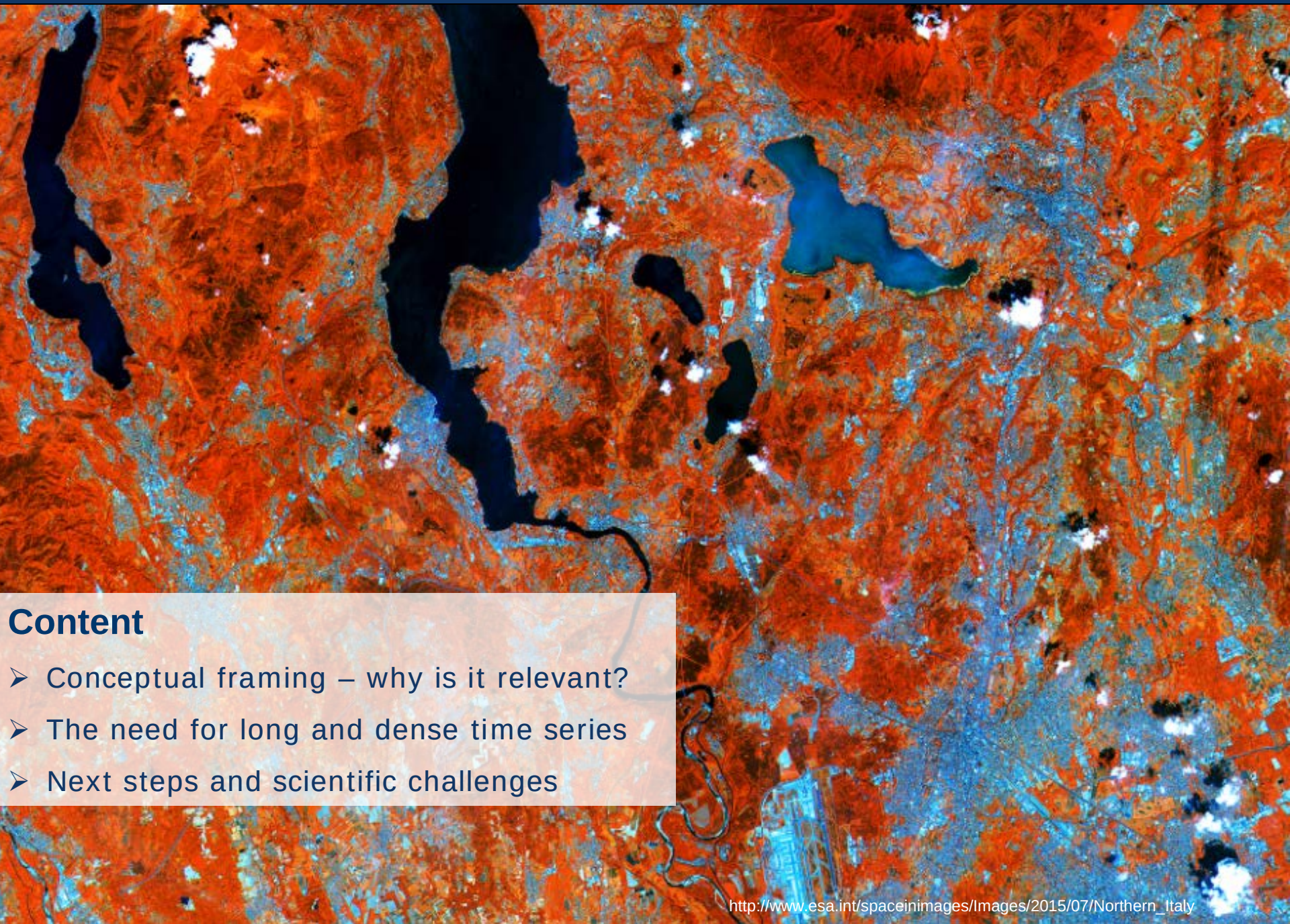


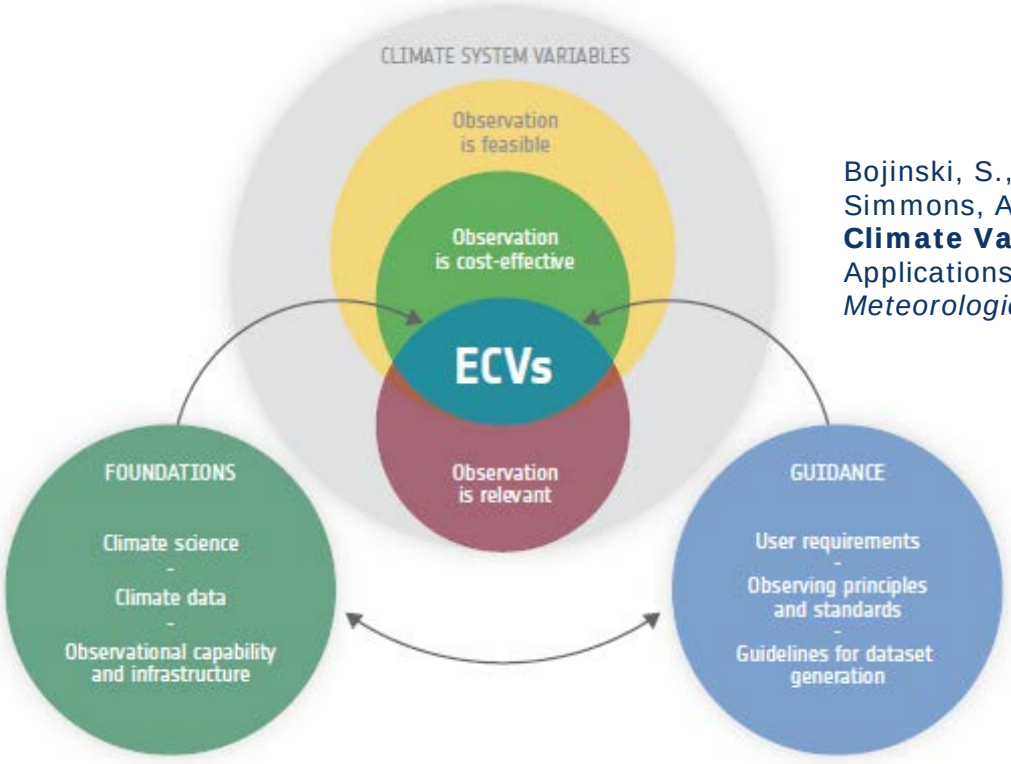
Content

- Conceptual framing – why is it relevant?
- The need for long and dense time series
- Next steps and scientific challenges

http://www.esa.int/spaceinimages/Images/2015/07/Northern_Italy

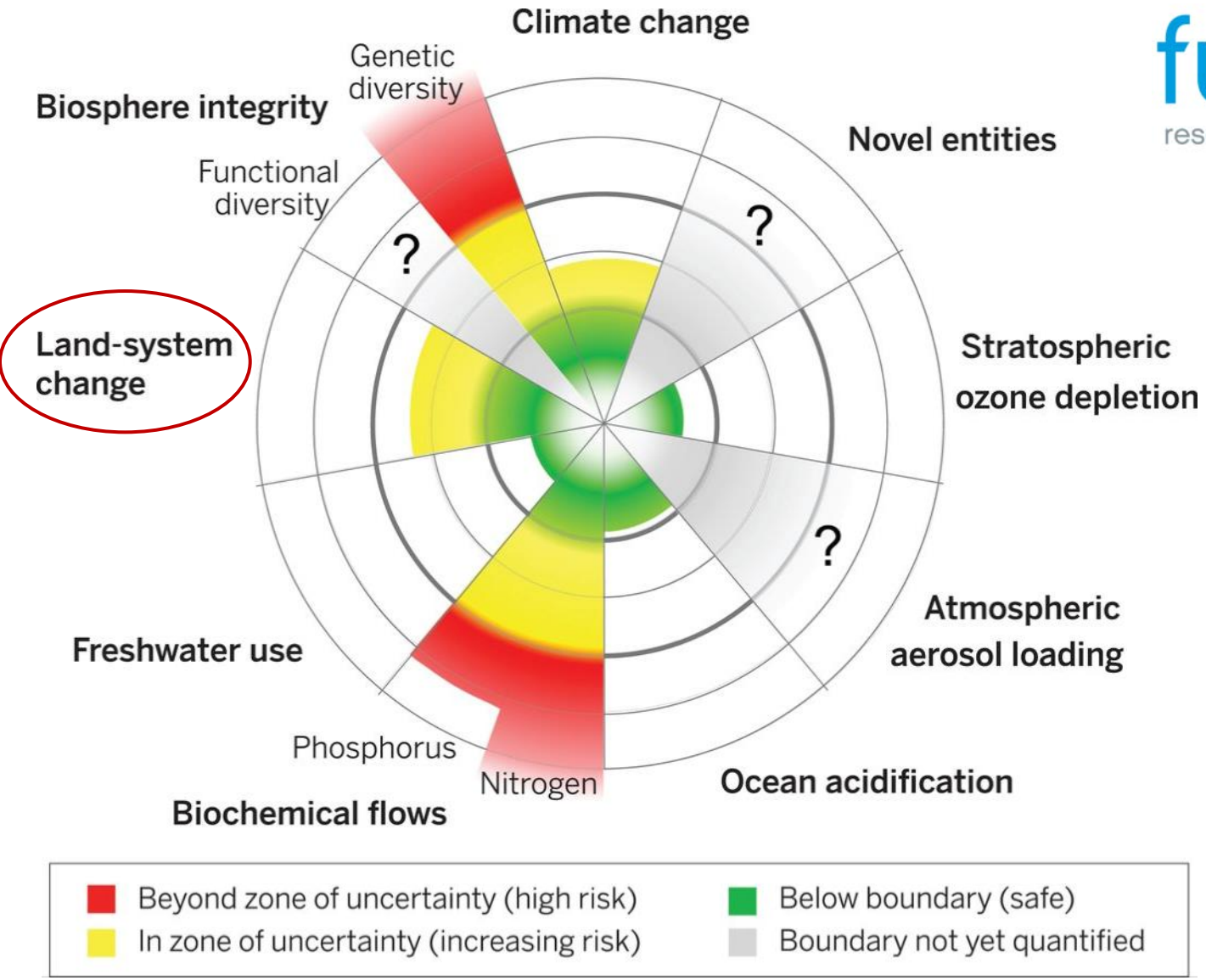
EO in support of climate change research: ECVs

- Without insights from satellite EO, there will be insufficient evidence to inform decision-makers
- Of 50 Essential Climate Variables defined by the Global Climate Observing System (GCOS), more than half include information from satellite observations



Bojinski, S., Verstraete, M., Peterson, T.C., Richter, C., Simmons, A., & Zemp, M. (2014). **The Concept of Essential Climate Variables in Support of Climate Research,** Applications, and Policy. *Bulletin of the American Meteorological Society, 95, 1431-1443*

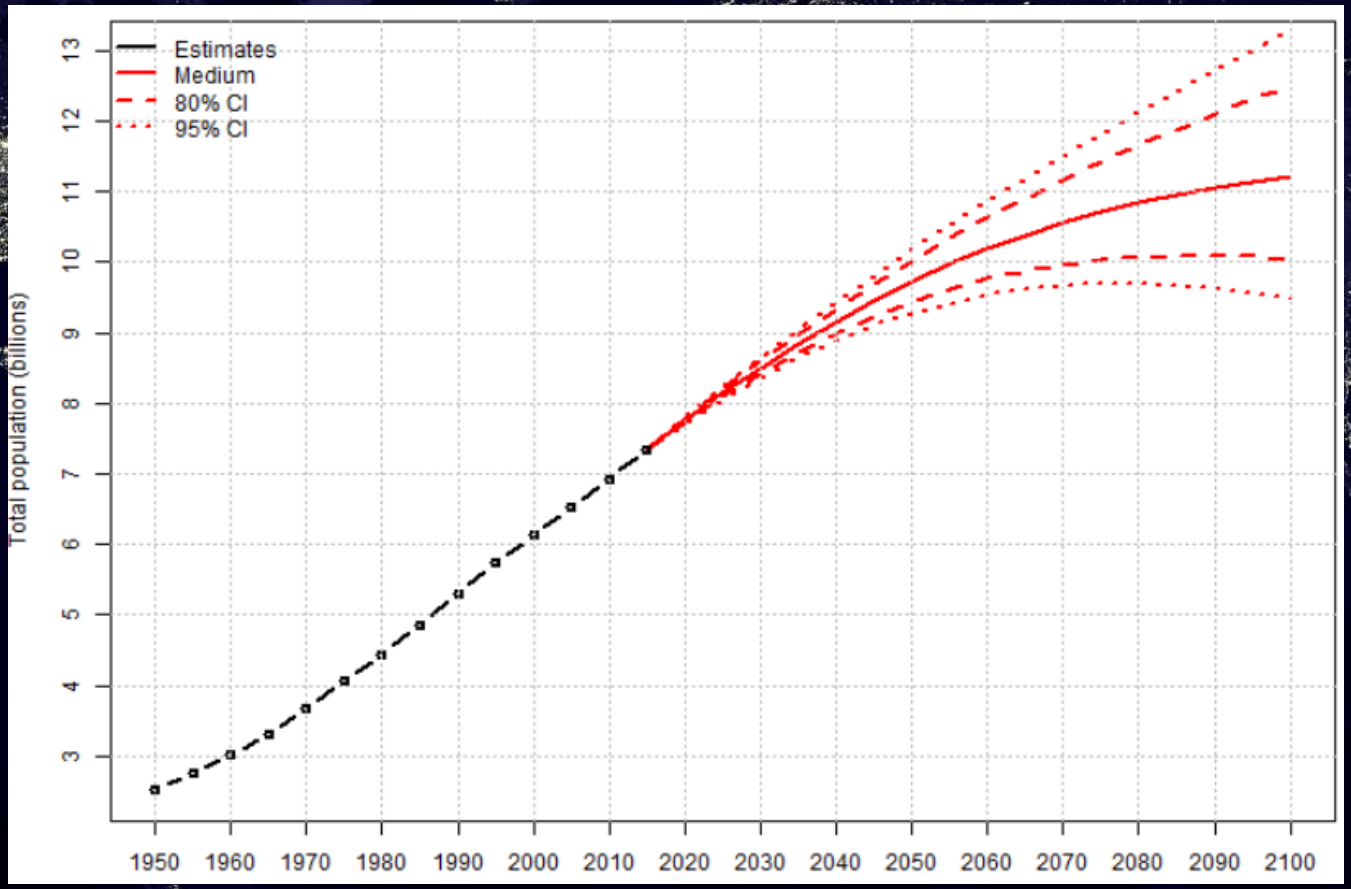
Land Systems Science



futureearth
research for global sustainability

Global LAND Project

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., & Sörlin, S. (2015). **Planetary boundaries: Guiding human development on a changing planet**. *Science*, 347

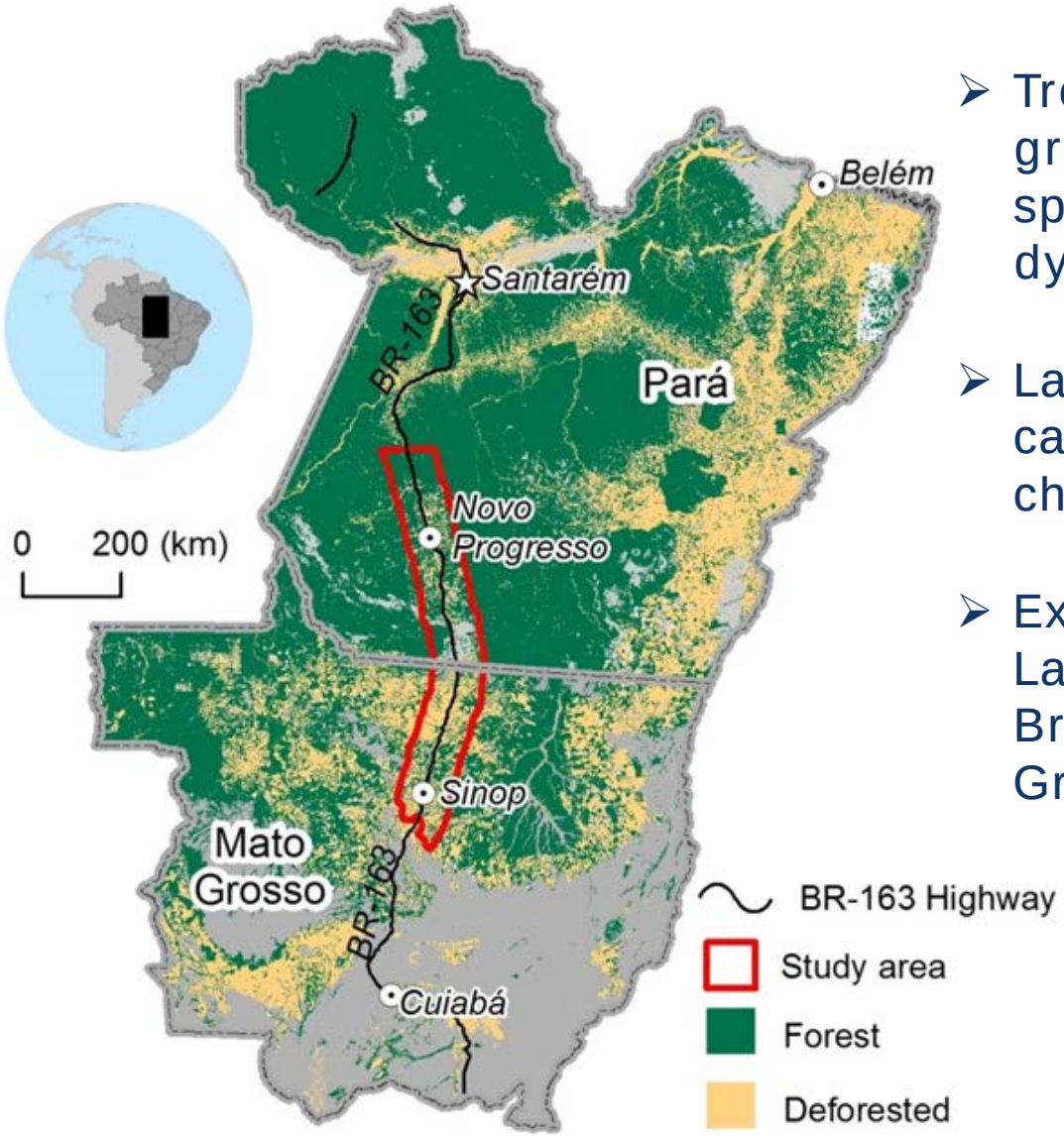


UN (2015): World Popluation Prospects: The 2015 Revision. Dept. Econ and Social Affairs, Popluation Division. UN, New York

Kofi Annan (2000): „We are entering the urban millenium“

http://apod.nasa.gov/apod/ap001127.html

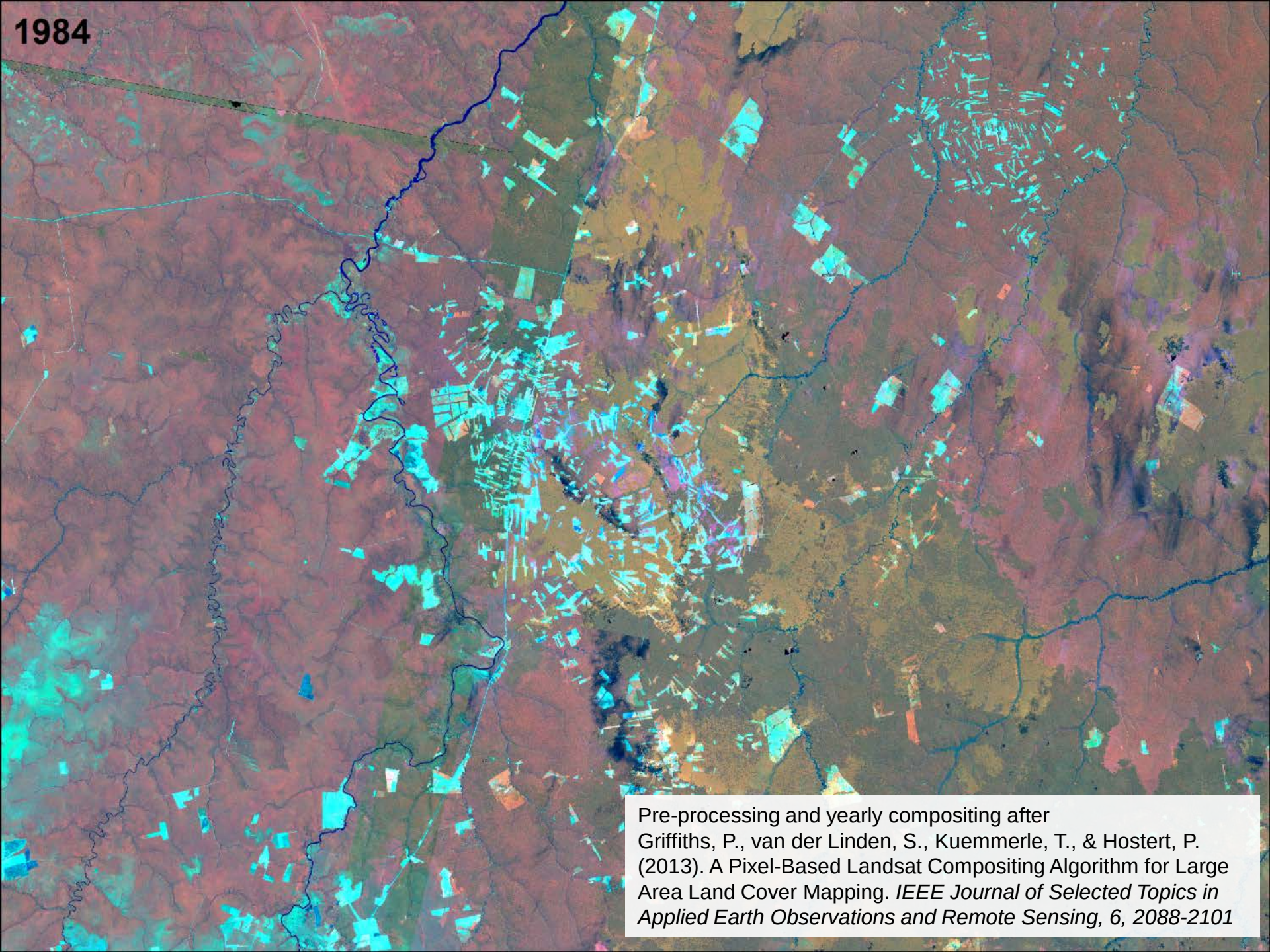
Reducing Emissions from Deforestation and Forest Degradation (REDD+): 30 years emission baseline



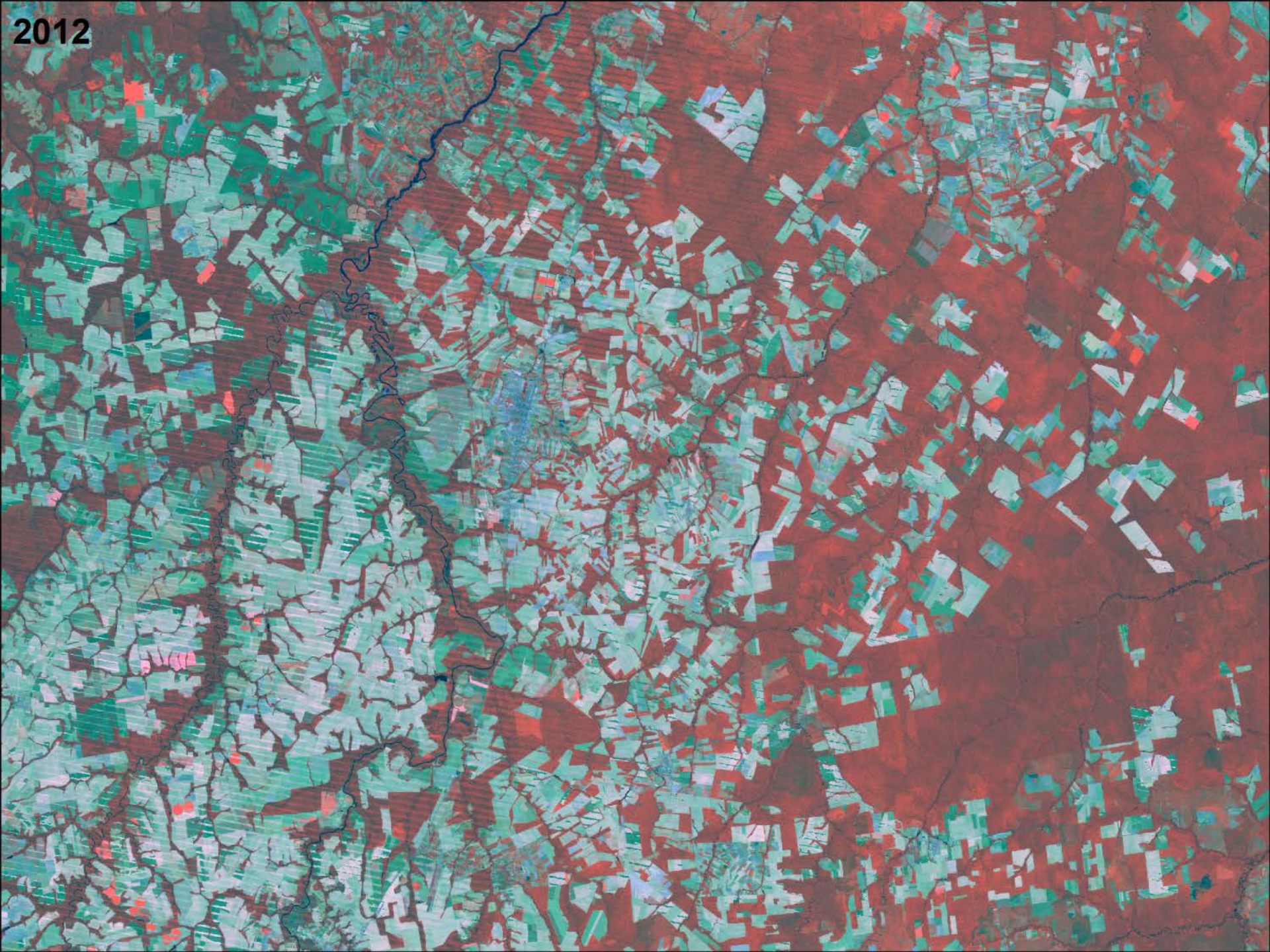
- Tropical deforestation and forest degradation estimates vary widely and spatio-temporal post-deforestation dynamics are largely unknown
- Land use is tightly connected with carbon budgets and with climate change
- Example based on ca. 60,000 Landsat images covering the Brazilian federal states of Mato Grosso and Pará since 1984

Hissa, L., Müller, H., Aguiar, A.P., Lakes, T., Hostert, P., in prep. **Emerging carbon emission patterns in a deforestation frontier: a case study for the BR-163, Southeastern Brazilian Amazonia**.

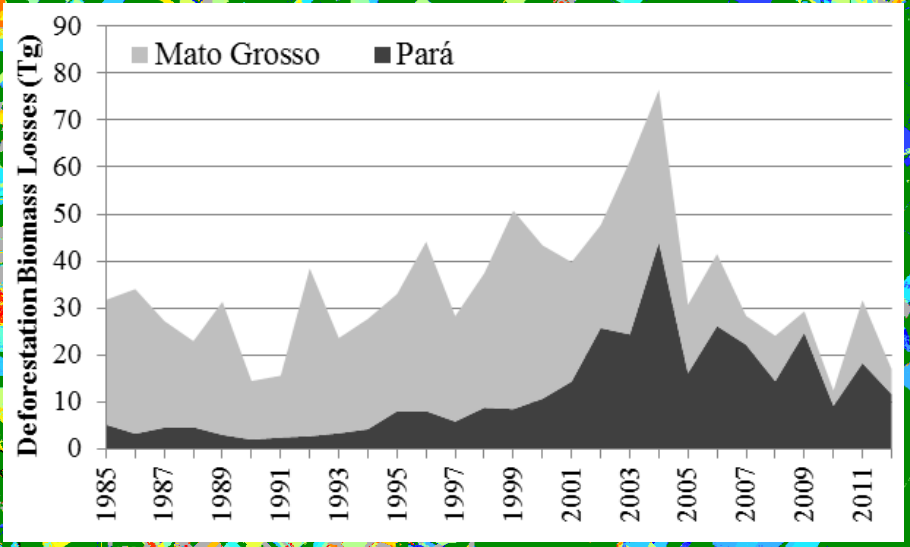
HU Berlin / INPE field campaign 2014 (© Taise Pinheiro)



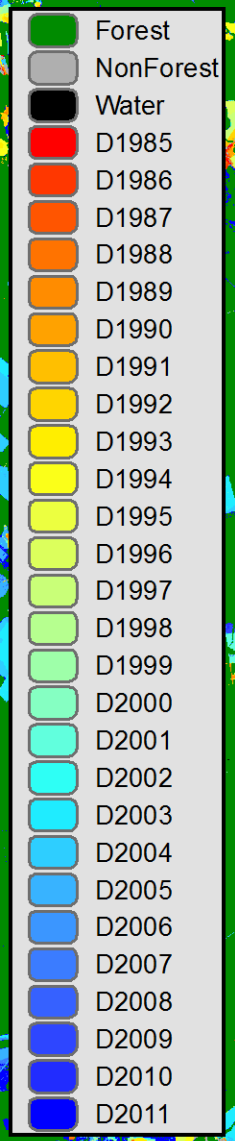
Pre-processing and yearly compositing after Griffiths, P., van der Linden, S., Kuemmerle, T., & Hostert, P. (2013). A Pixel-Based Landsat Compositing Algorithm for Large Area Land Cover Mapping. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 6, 2088-2101*


2012

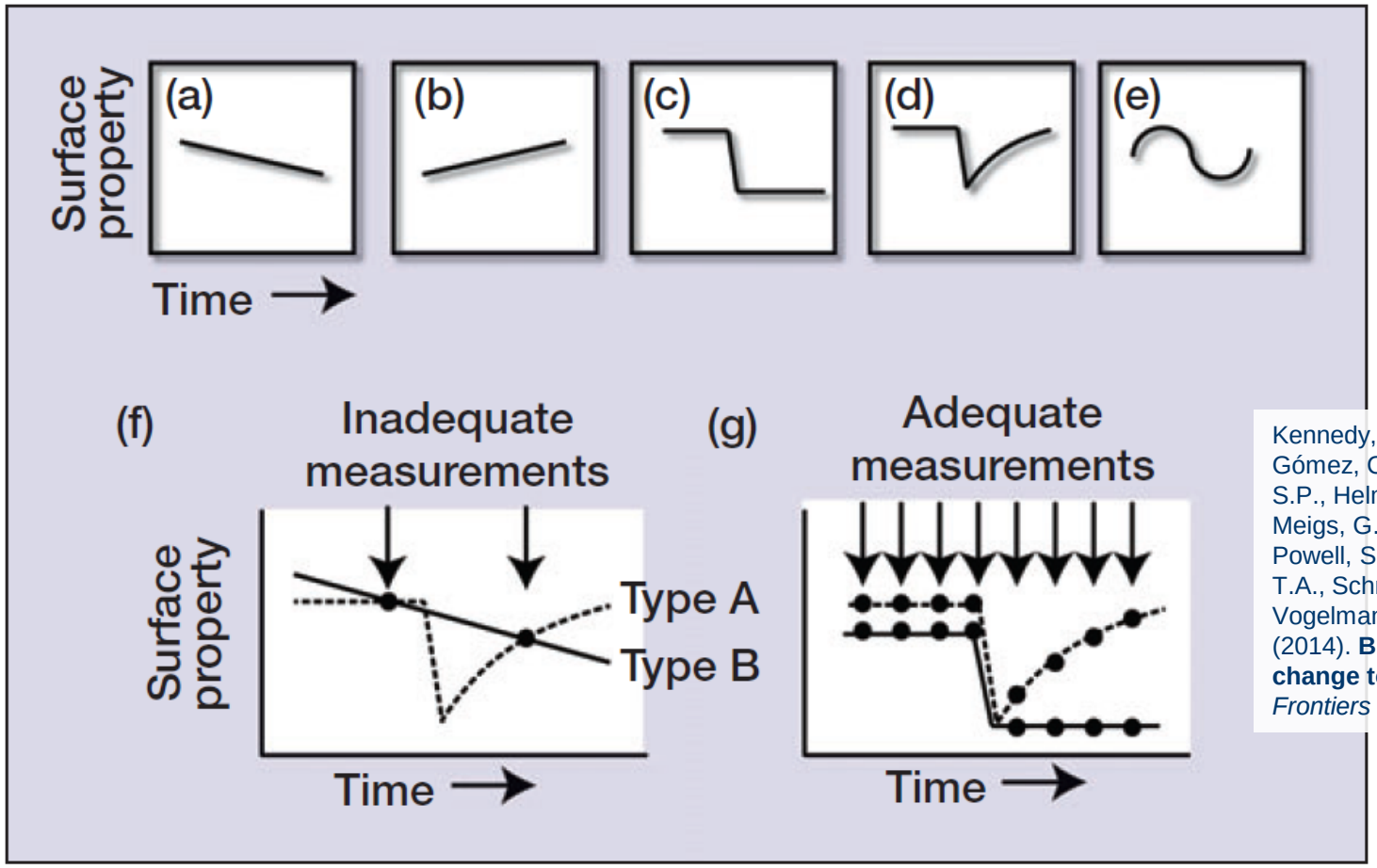
- Yearly maps of de-forestation, degradation and post-disturbance dynamics are needed for up-to-date carbon estimates



Hissa, L., Müller, H., Aguiar, A.P., Lakes, T., Hostert, P., in prep. **Emerging carbon emission patterns in a deforestation frontier: a case study for the BR-163, Southeastern Brazilian Amazonia.**



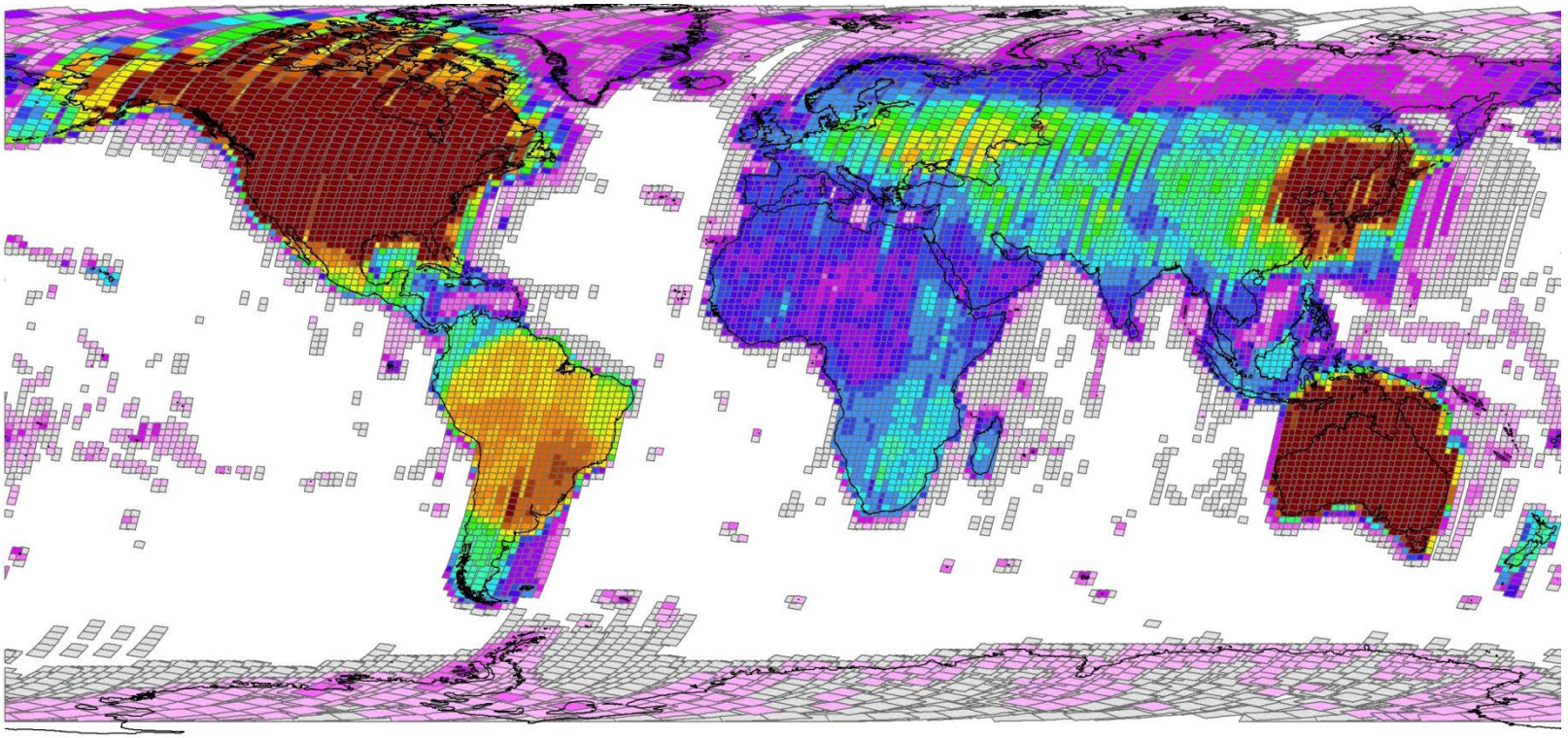
The need for long and dense time series



Kennedy, R.E., Andréfouët, S., Cohen, W.B., Gómez, C., Griffiths, P., Hais, M., Healey, S.P., Helmer, E.H., Hostert, P., Lyons, M.B., Meigs, G.W., Pflugmacher, D., Phinn, S.R., Powell, S.L., Scarth, P., Sen, S., Schroeder, T.A., Schneider, A., Sonnenschein, R., Vogelmann, J.E., Wulder, M.A., & Zhu, Z. (2014). **Bringing an ecological view of change to Landsat-based remote sensing**. *Frontiers in Ecology and the Environment*

- Time series often need to be long (i.e. decades) to monitor processes relevant to land and climate systems change (e.g. baseline scenarios)
- Time series often need to be dense (e.g. weekly) to allow tracking phenology of relevant (change) processes or compositing cloud free data

USGS Landsat archive up to Jan 1, 2015



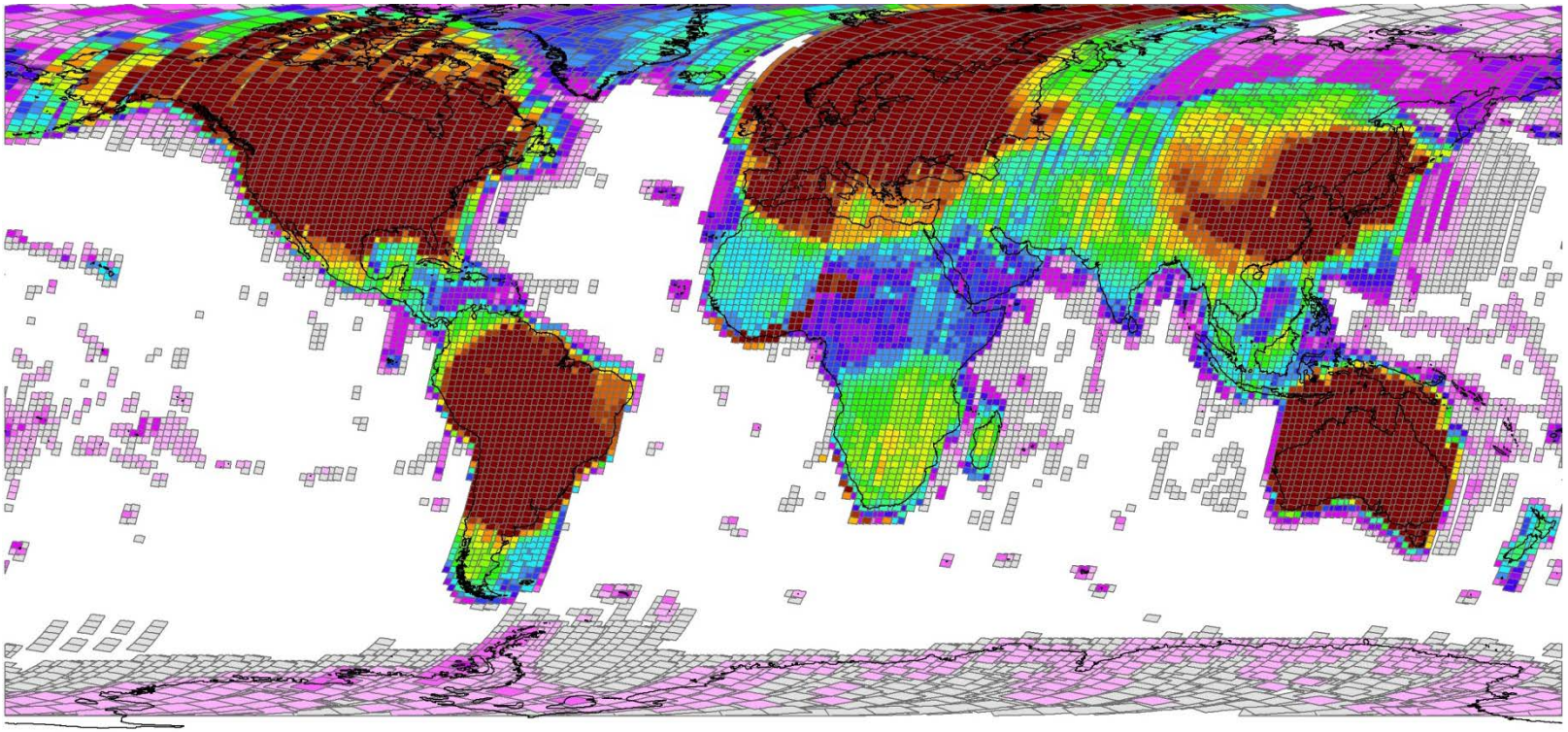
Number of images

1-50	200-250	400-450	600-650	800-850
50-100	250-300	450-500	650-700	850-900
100-150	300-350	500-550	700-750	900-950
150-200	350-400	550-600	750-800	>950

Archive holdings as of January 1, 2015

Wulder, M.A., White, J.O., Loveland, T.R., Woodcock, C.E., Belward, A.S., Cohen, W.B., Fosnight, E.A., Shaw, J., Masek, J.G., Roy, D.P., in prep. **The global Landsat 1 archive: Status, consolidation, and direction**

Future Landsat archive once outstanding images added



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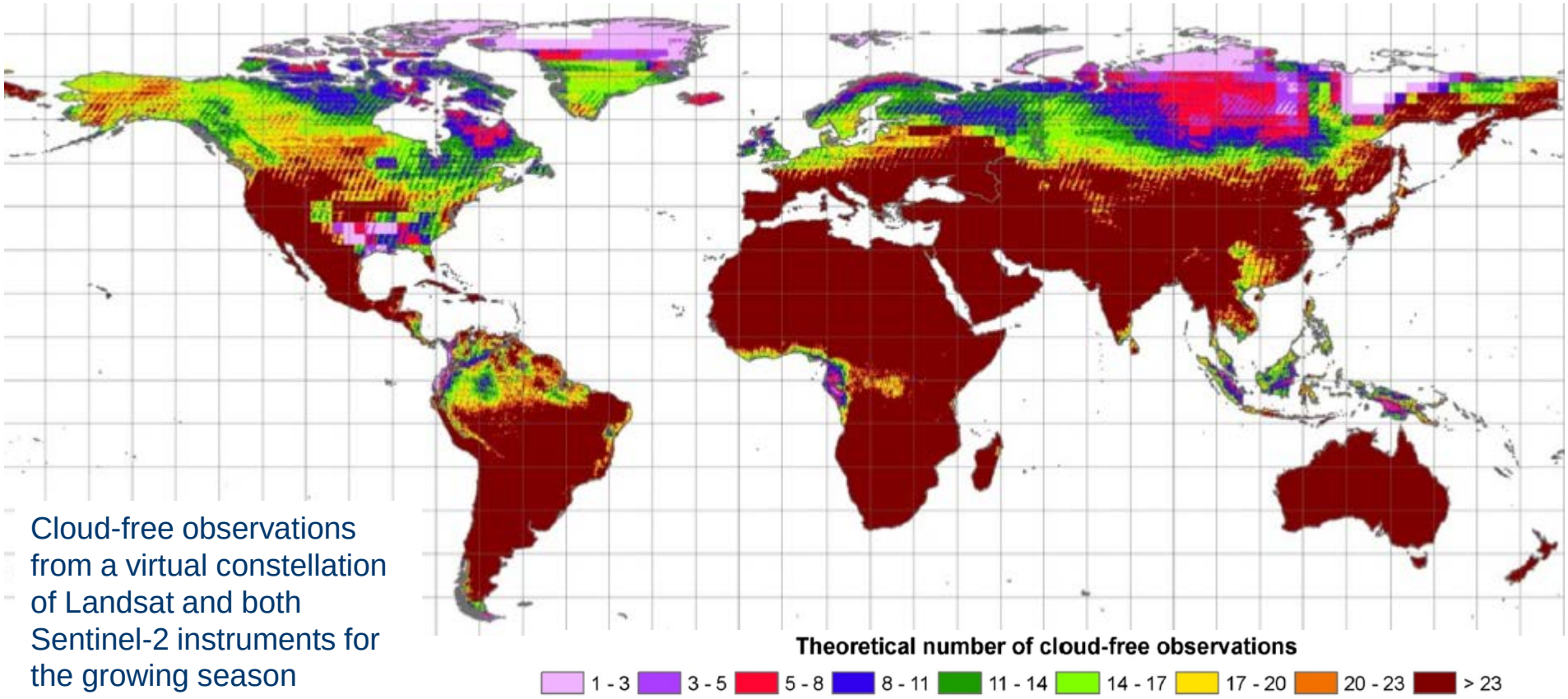
Potential future archive holdings (with LGAC)

Wulder, M.A., White, J.O., Loveland, T.R., Woodcock, C.E., Belward, A.S., Cohen, W.B., Fosnight, E.A., Shaw, J., Masek, J.G., Roy, D.P., in prep. **The global Landsat 1 archive: Status, consolidation, and direction**

Next steps and scientific user needs

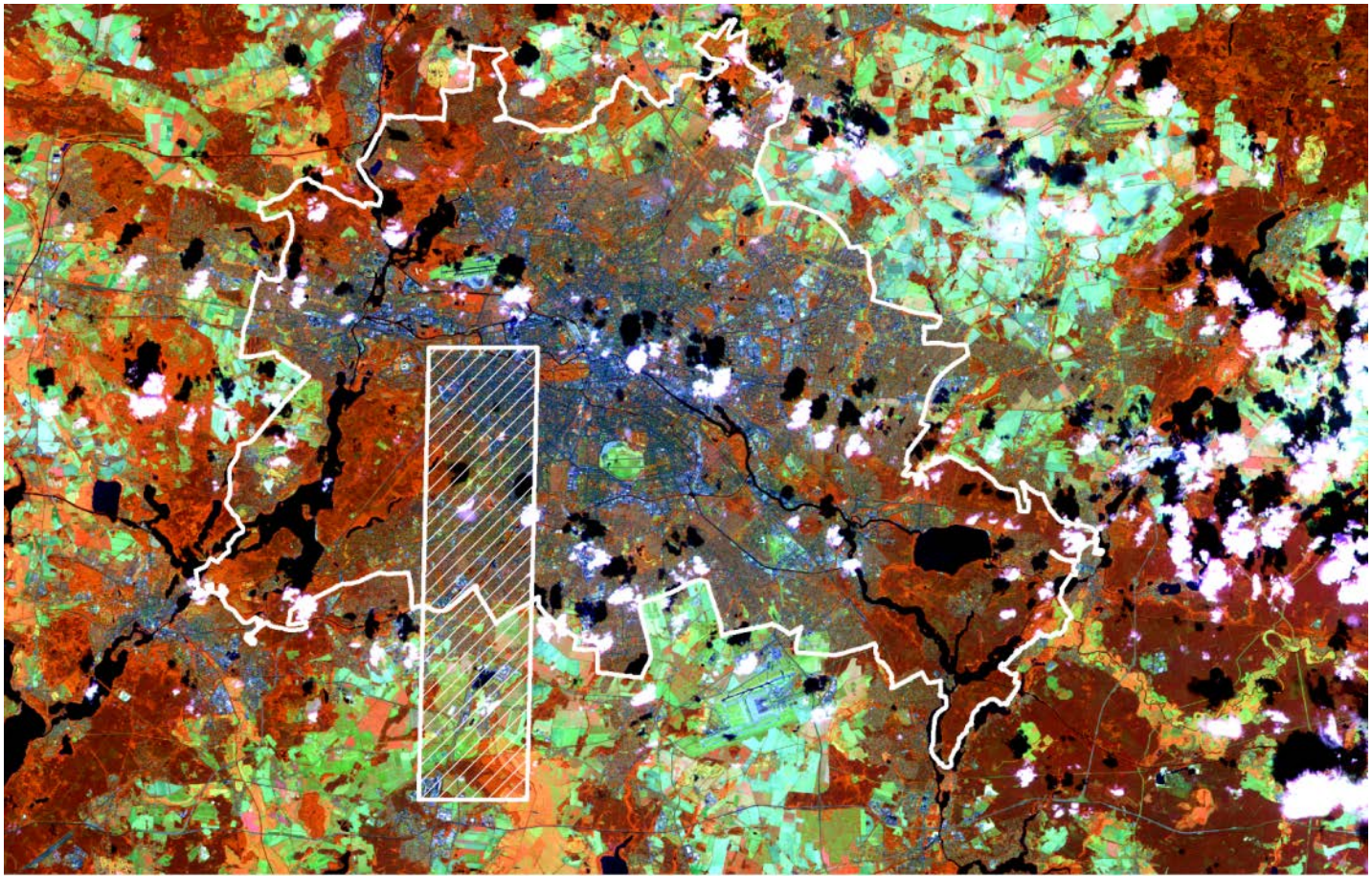
- **Accurate pre-processing** (e.g. Landsat level 1T/2a, Sentinel-2 1C/2a) to allow integrating different sensors into streamlined analyses



Cloud-free observations from a virtual constellation of Landsat and both Sentinel-2 instruments for the growing season

Wulder, M.A., Hilker, T., White, J.C., Coops, N.C., Masek, J.G., Pflugmacher, D., & Crevier, Y. (2015). **Virtual constellations for global terrestrial monitoring**. *Remote Sensing of Environment, 170, 62-76*

Sentinel-2 data availability will change the scene
Example imperviousness mapping



Berlin

23.08.2015

10 m

R=842 nm (B08)

G=1610 nm (B11)

B=560 nm (B03)

- **S2A_OPER_PRD_MSIL1C_PDMC_20150823T120312_R022_V20150823T101641_20150823T101641**

Hostert, P., Pflugmacher, D., Okujeni, A., van der Linden, S., Rabe A., Griffiths, P. **Sentinel-2 for enhanced land systems monitoring.** Presentation at the Sentinel-2 Expert Users Technical Meeting, 29-30 Sept 2015, ESA-ESRIN, Frascati, Italy.

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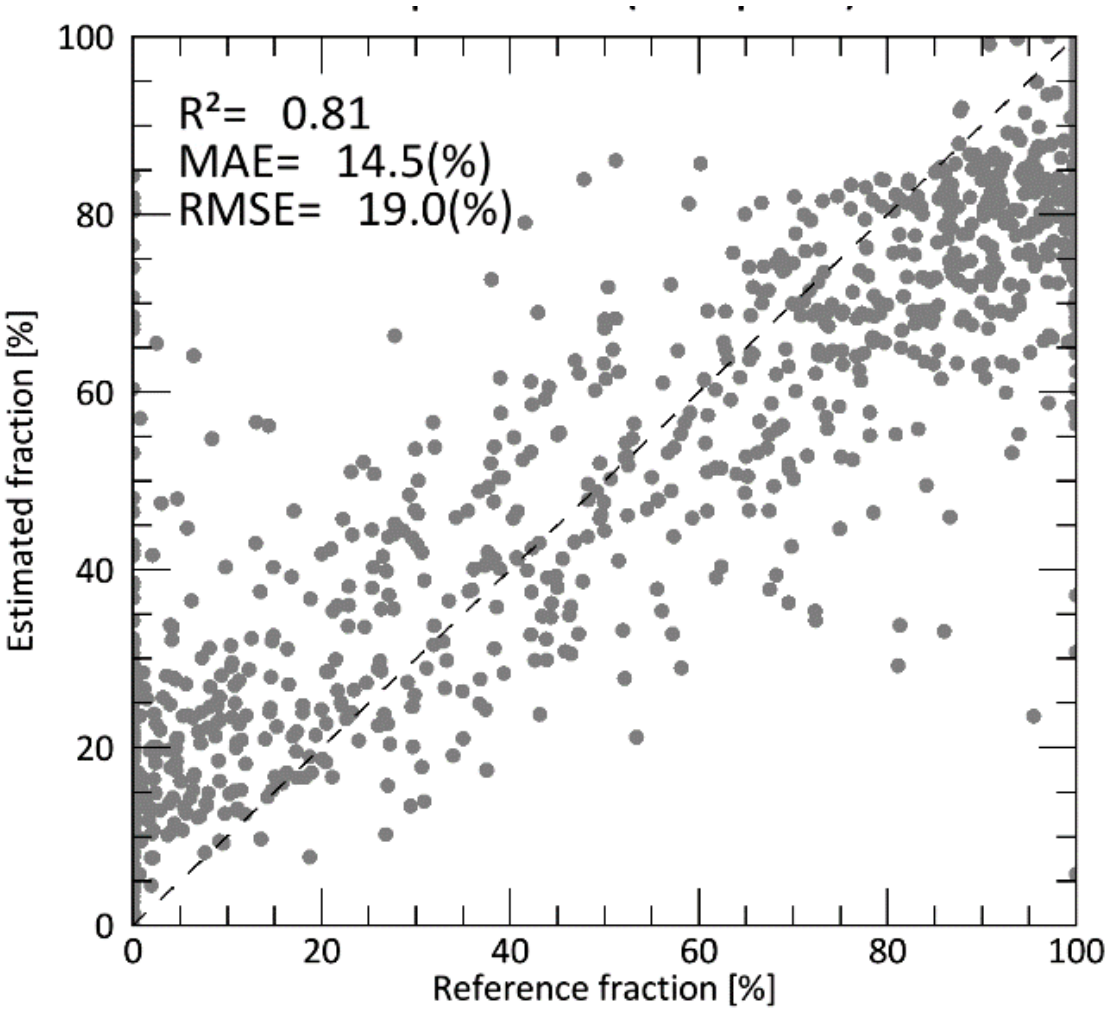
Example imperviousness mapping

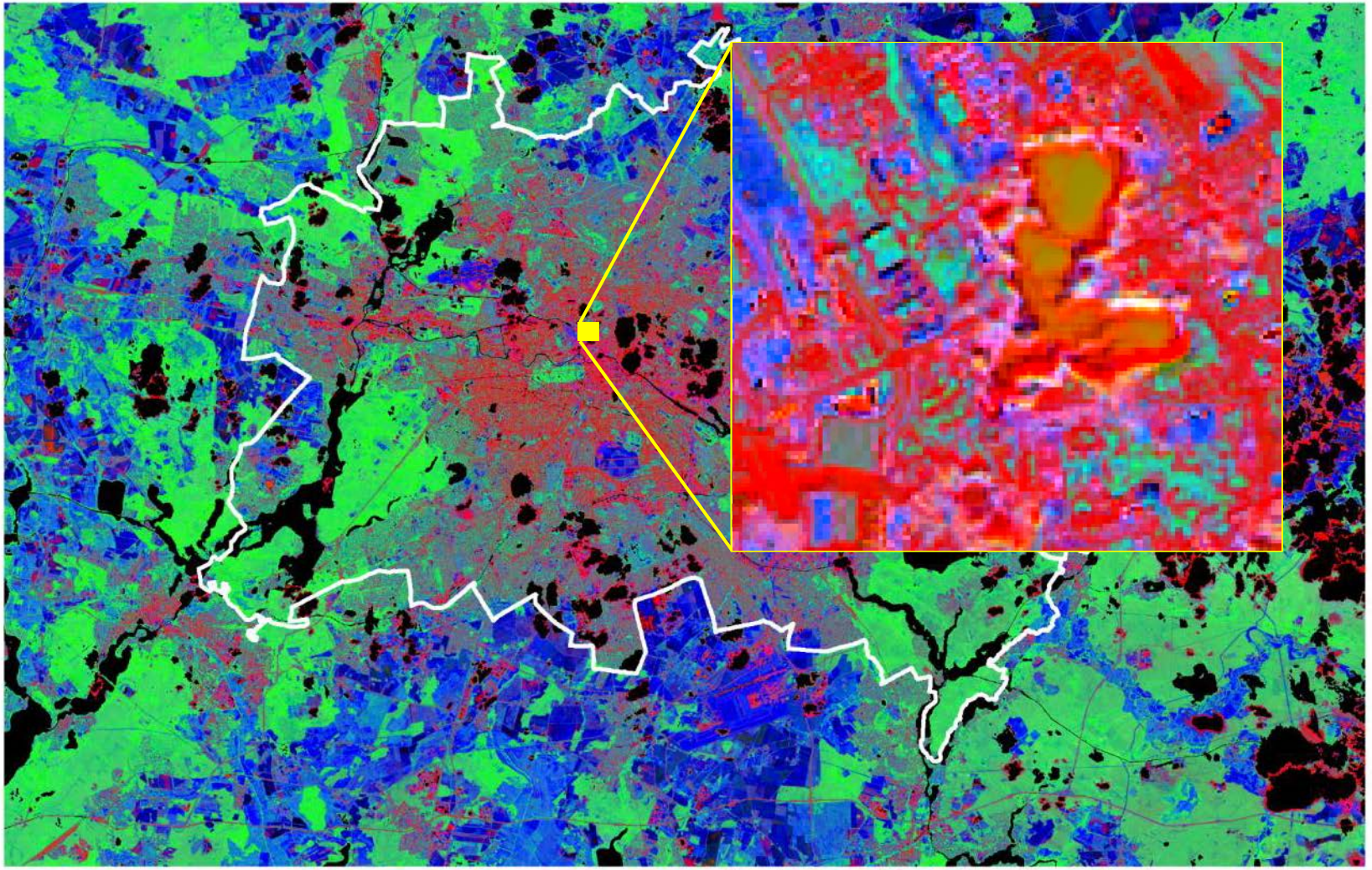


- Impervious–Vegetation–Tree mapping based on support vector regression
- Imperviousness estimates >80% accurate at 20m level

Methods adapted from

Okujeni, A., van der Linden, S., & Hostert, P., 2015. **Extending the vegetation–impervious–soil model using simulated EnMAP data and machine learning**. *Remote Sensing of Environment, 158, 69-80*

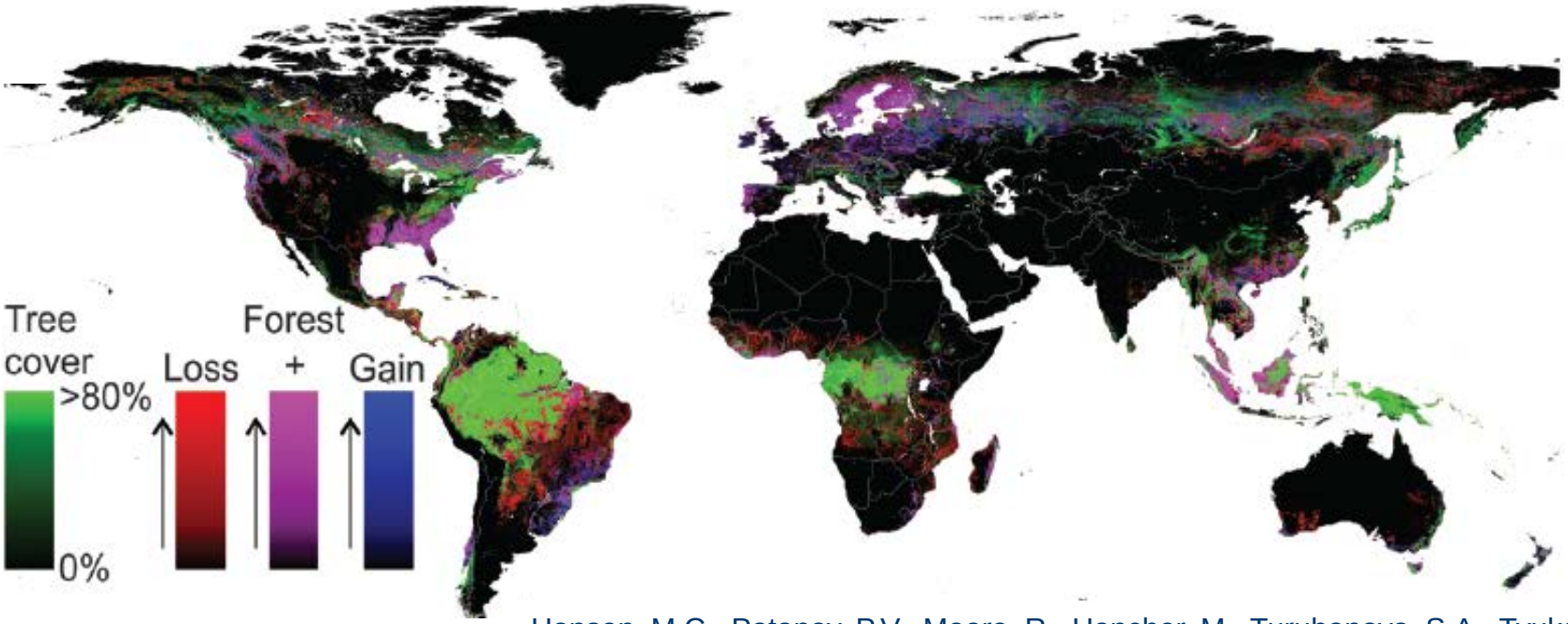
Sentinel-2 data availability will change the scene
Example imperviousness mapping



R = Impervious, G = Tree, B = Low vegetation

Next steps and scientific user needs

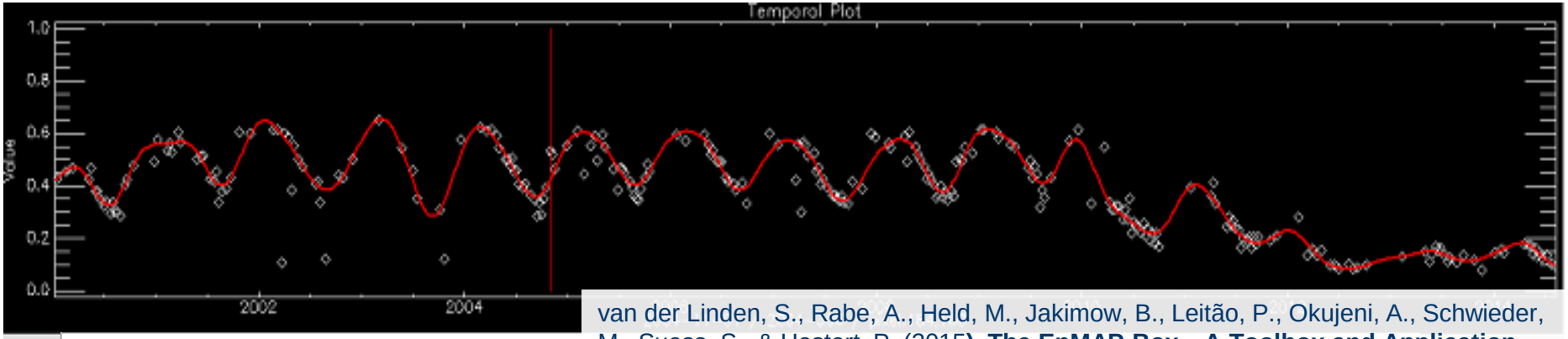
- One important step taken - **open archives** and free data access: Sentinels, Landsat, and more to come
- From access to usability: affordable Pbyte **cloud storage / processing**
- available soon: S2-Landsat legacy bands at USGS / GEE



Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyuka-vina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., & Townshend, J.R.G. (2013). **High-Resolution Global Maps of 21st-Century Forest Cover Change**. Science, 342, 850-853

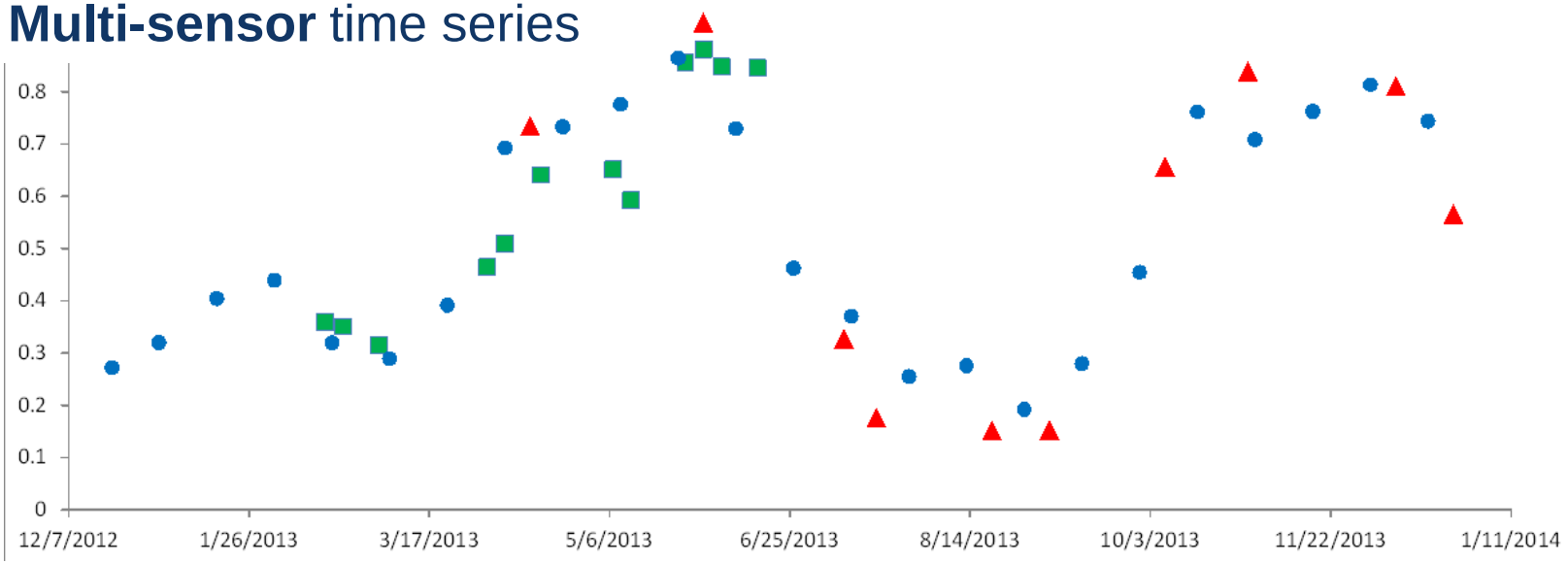
Next steps and scientific user needs

- **Better tools** (e.g. machine learners - RF, SVM) to integrate 100s of observations per pixel – for large areas, over time *and across sensors*



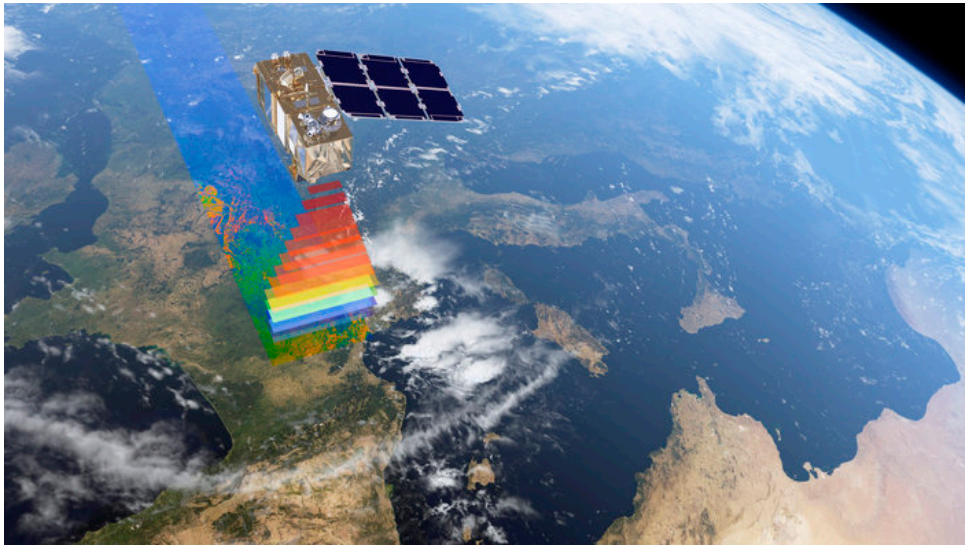
van der Linden, S., Rabe, A., Held, M., Jakimow, B., Leitão, P., Okujeni, A., Schwieder, M., Suess, S., & Hostert, P. (2015**). The EnMAP-Box—A Toolbox and Application Programming Interface for EnMAP Data Processing**. *Remote Sensing, 7, 11249*

- **Multi-sensor** time series



The way ahead

- Improved temporal resolution (timeliness, observation density) at appropriate scales -> phenological analyses
- Create stronger links to ecosystem services: agricultural production, yield gaps, ecological restoration potential, carbon storage, …
- linking Sentinel2a/b and Landsat!



Launch of Landsat 8 (NASA, 2013)

Sentinel-2: „Colour vision for Copernicus“ (ESA/ATG medialab 2015)

Don’t blow it – good planets are hard to find…

Time Magazin 2001

Acknowledgments:

- Landsat Science Team
- Global Land Project
- EU funding for I-REDD+
- BMWi funding for SenseCarbon and EnMAP
- BMBF funding for CarBioCial
- ESA funding for Island2VAP
- We greatly appreciate ESA pre-operational expert user access to Sentinel-2 data.