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Remote sensing of forest plantations: past and future

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Correalização: ibá indústria brasileira de árvores; IPEF

Remote sensing of forest plantations: past and future

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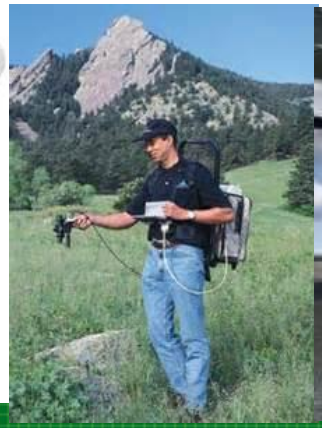
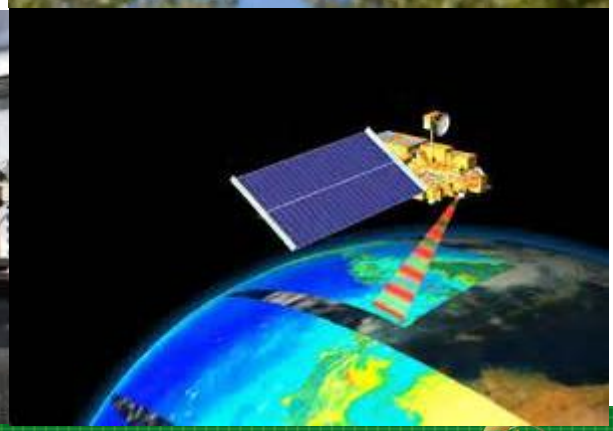
LA RECHERCHE AGRONOMIQUE POUR LE DÉVELOPPEMENT

- What is remote sensing ?
- Earth Observation satellites
- Main use of EO for forest monitoring
- Examples on Eucalypt plantations in Brazil
- Taking forest plantation to the space age !

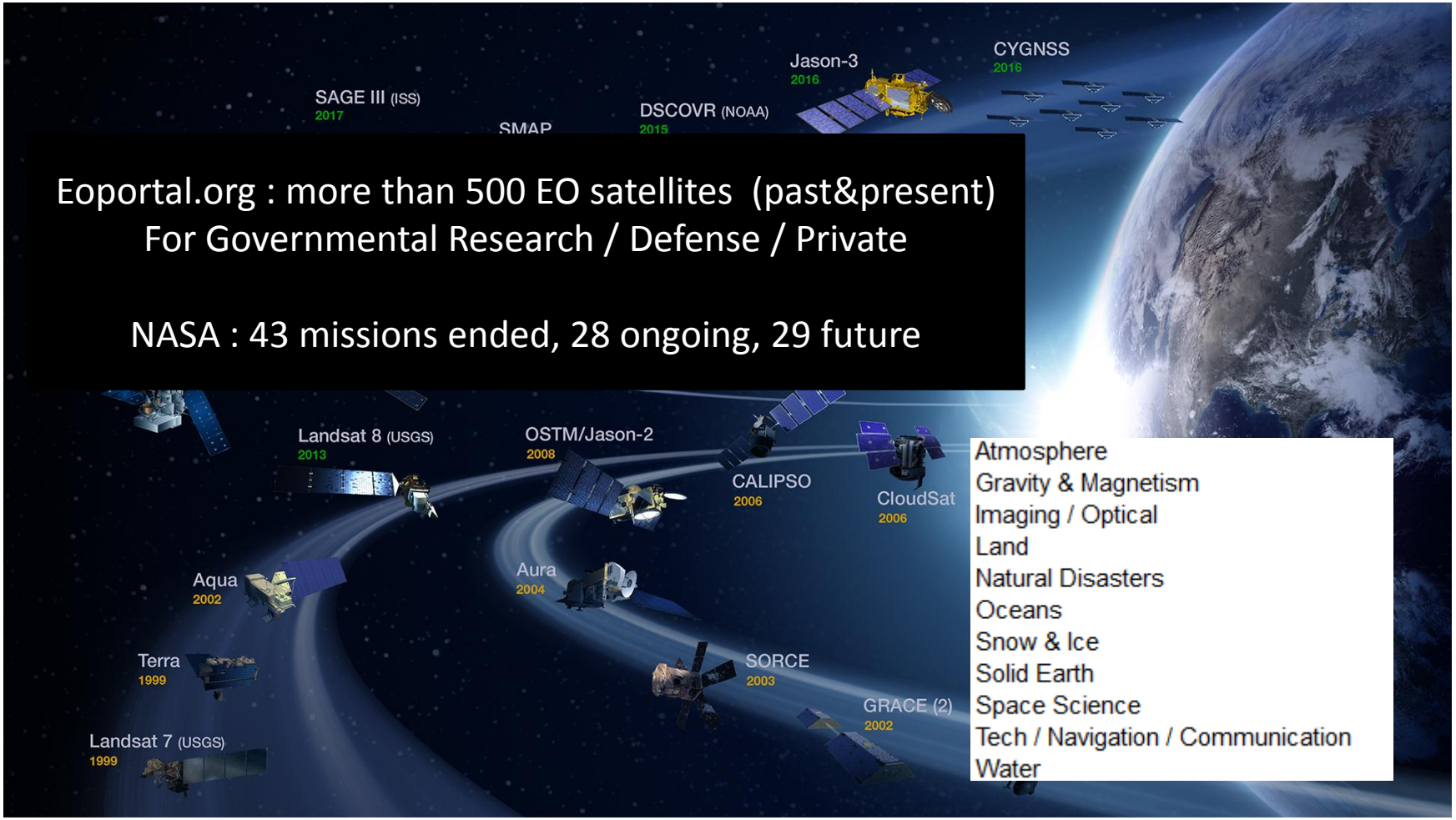
What is remote sensing ?

- Acquisition of information without contact
  - Leaves/trunk (hand-held devices)
  - Canopy (from towers)
  - Airborne sensors (local/regional)
  - Satellite sensors (regional/global)





Earth Observation satellites



Eoportal.org : more than 500 EO satellites (past&present)
For Governmental Research / Defense / Private

NASA : 43 missions ended, 28 ongoing, 29 future

@ https://eospso.nasa.gov/

Earth Observation satellites

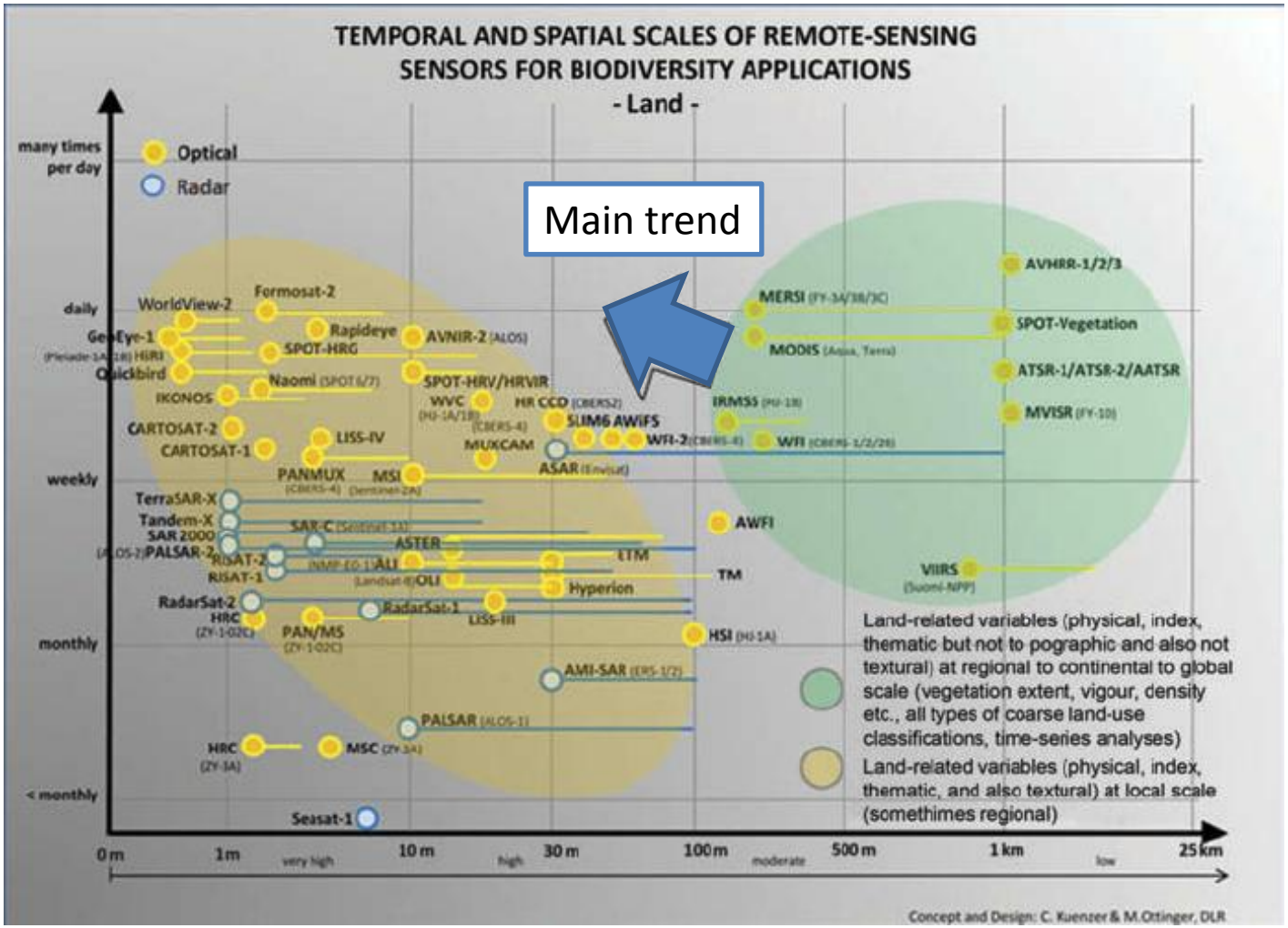
Main differences between EO sensors :

- **Spectral**: type of electromagnetic radiation (visible, infrared, thermal IR, radar…); passive vs. active; spectral resolution; radiometric resolution
- **Spatial**: resolution of the image in ground meters (from~0.5 m to 1km pixel sizes), size of the image
- **Temporal**: frequency of flyovers (day to months)

Earth Observation satellites

- **Data continuity**: important for development and research investment
- **Data accessibility**: cost, delay, format, softwares, etc.

Earth Observation satellites



Main use of EO for forest monitoring

- **Classification of land use and land use changes**

  Maps; plannification; extreme events impacts; …

- **Estimation of biochemical and structural variables**

  Tree counting; biomass/height/volume; Leaf area index; chlorophyll/nitrogen content; …

- **Plant water status**

  Leaf water content; evapotranspiration; soil moisture; fluorescence; light use efficiency; …

- **Monitoring and management**

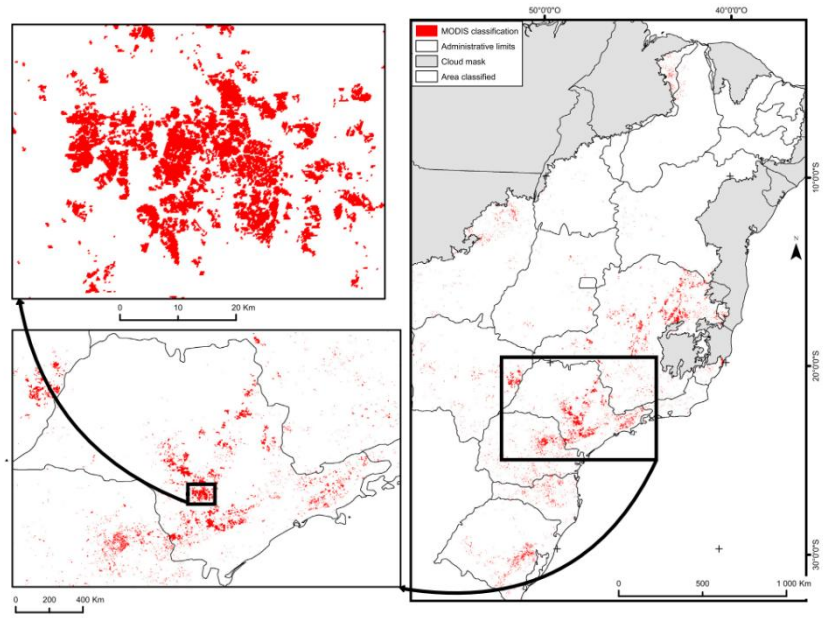
  Stand history; fire risk; …

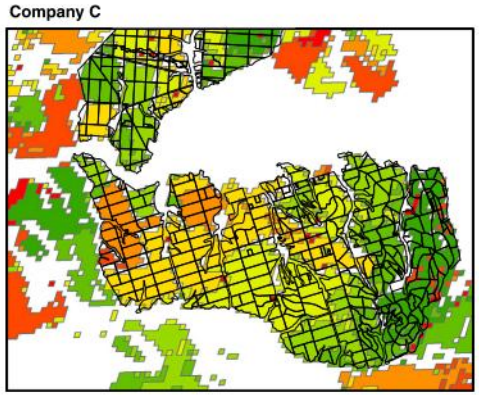
Main use of EO for forest monitoring

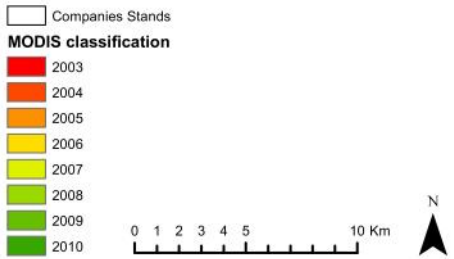
- Many possible use… but drawbacks:
  - Estimations come with uncertainties
  - Applicability and operationality not guaranteed
  - Need of field measurements for cal / val
  - High degree of technicity
  - Uncertain (clouds, satelite breackdown…)

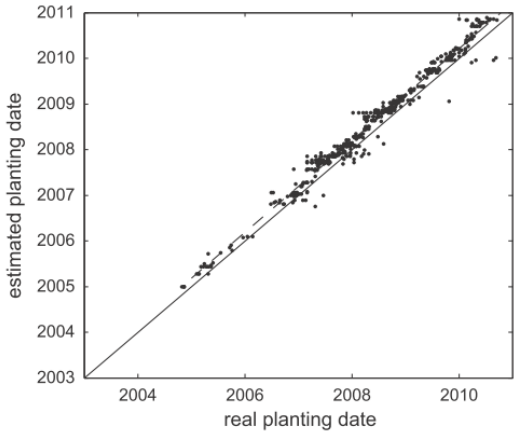
Examples on Eucalypt plantations

- Map, planting dates





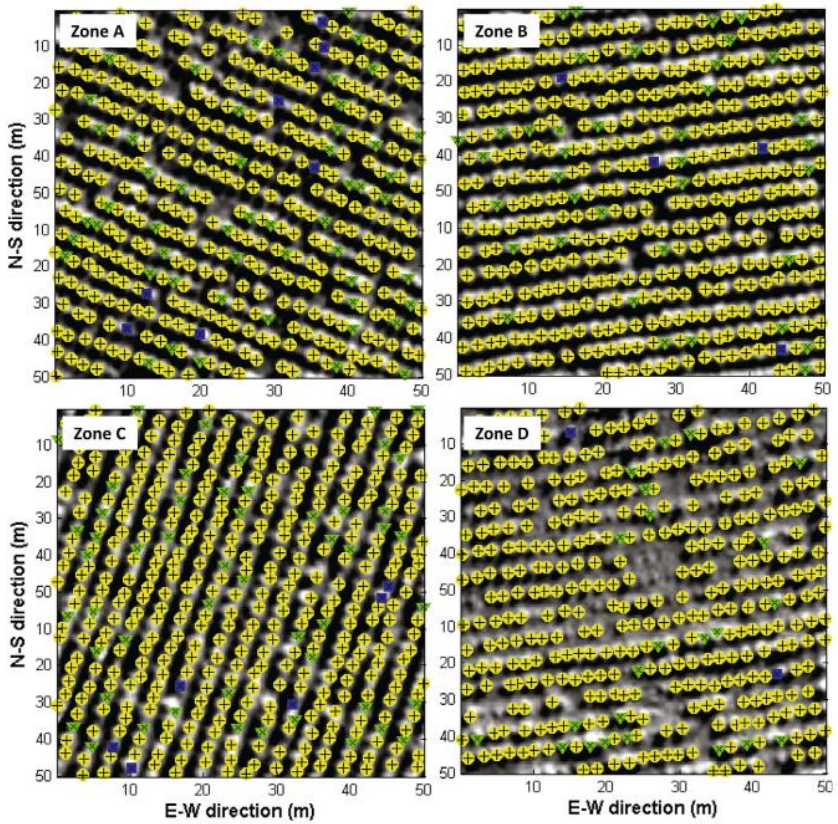


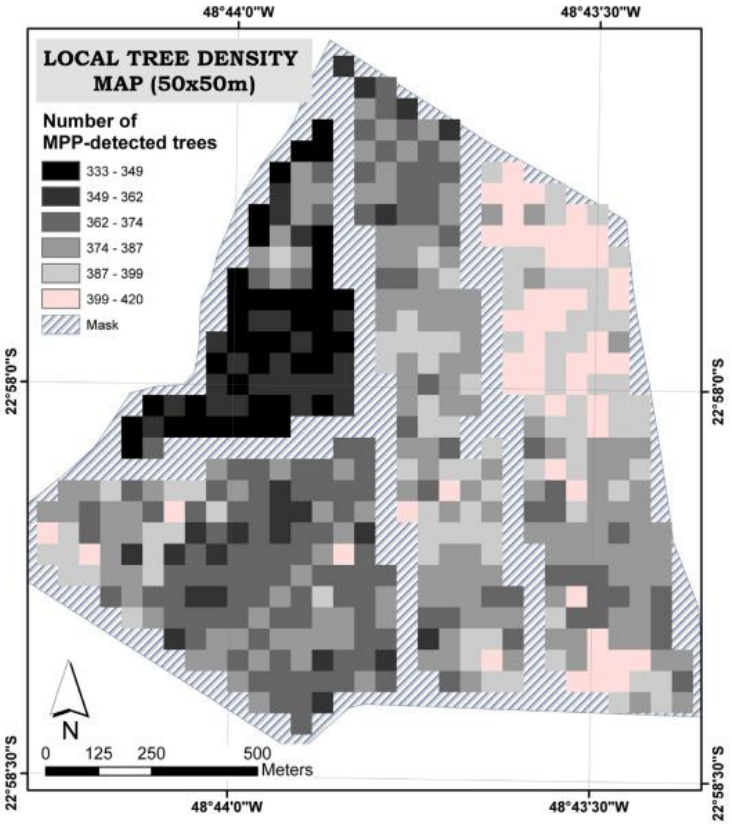


Le Maire et al., 2014, Remote Sensing of Environment
http://dx.doi.org/10.1016/j.rse.2014.05.015

Examples on Eucalypt plantations

- Tree counting at initial stage



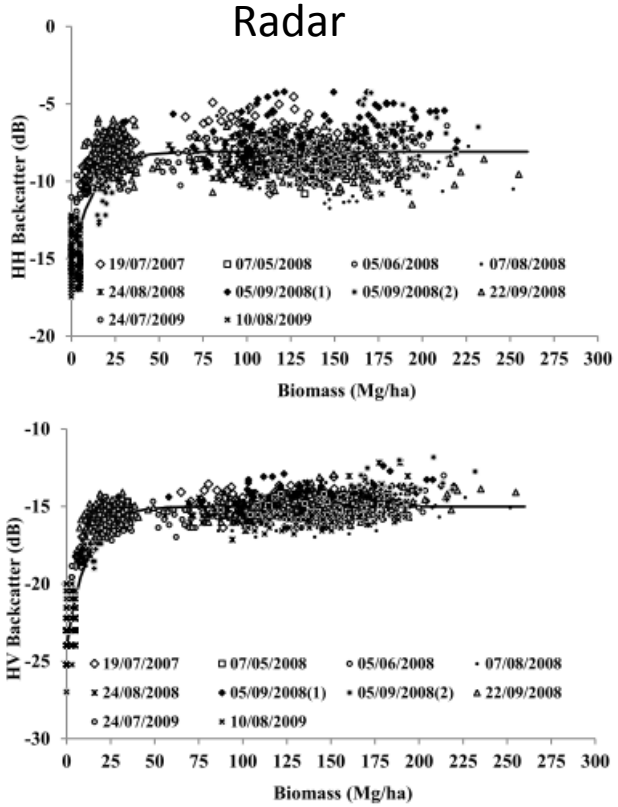


Zhou et al, 2013, Forest Ecology and Management
http://dx.doi.org/10.1016/j.foreco.2012.10.00

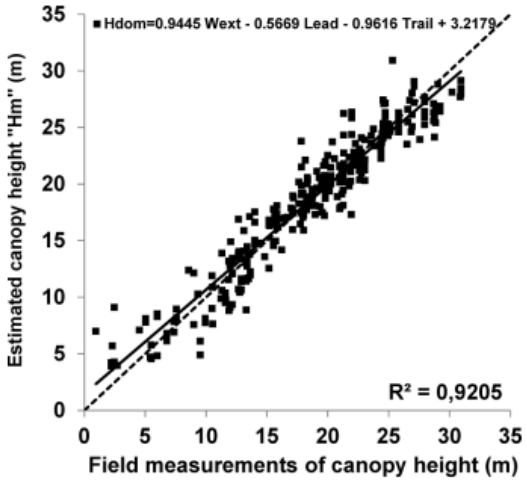
Examples on Eucalypt plantations

- Biomass estimation (or volume, mean height)

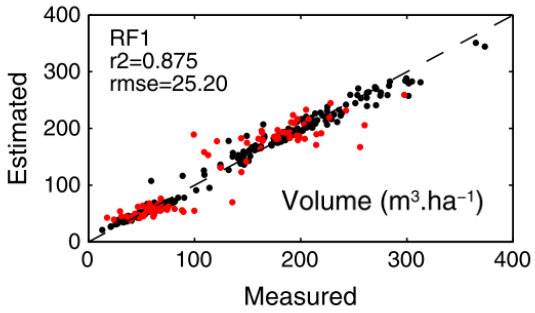
Radar

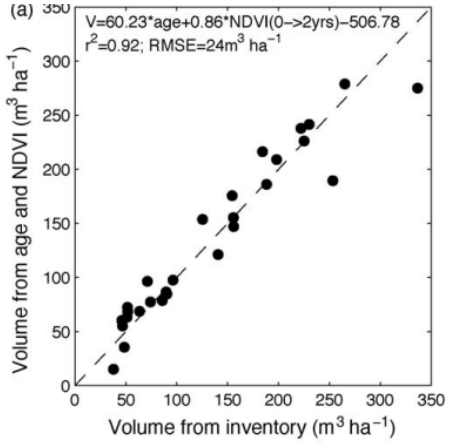


Satellite lidar



Optical time-series





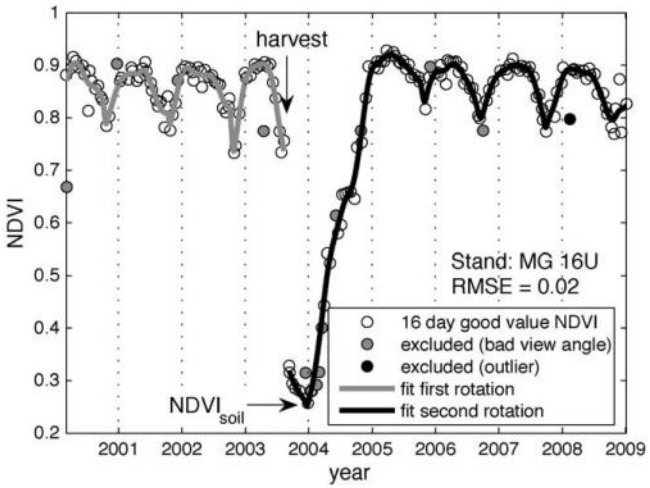
Baghdadi, 2014, JSTARS
https://doi.org/10.1109/JSTARS.2014.2353661

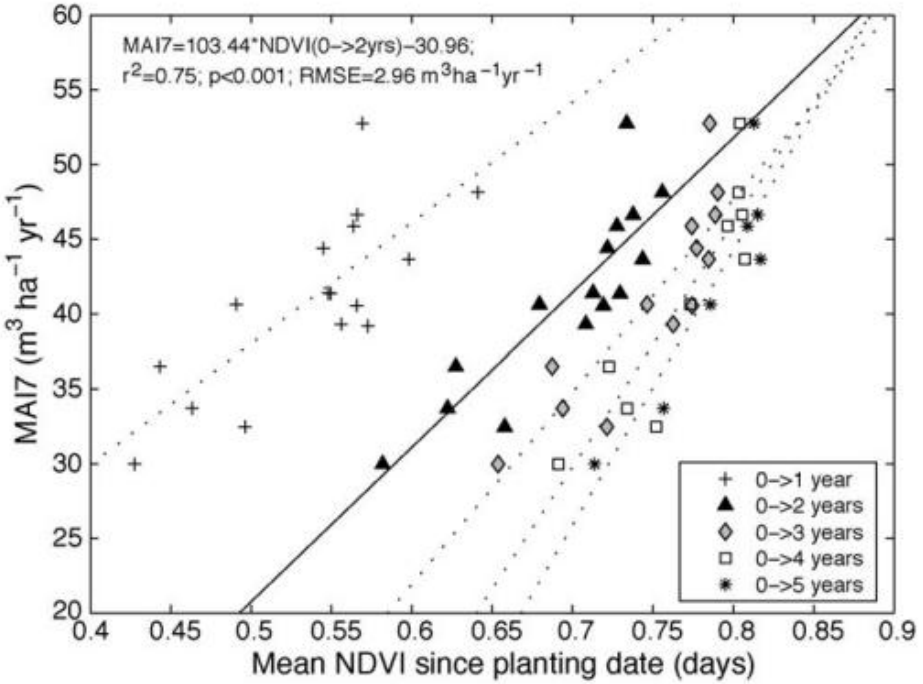
Baghdadi, 2013, JSTARS
https://doi.org/10.1109/JSTARS.2013.2261978

Le Maire et al. , 2011, RSE
http://dx.doi.org/10.1016/j.rse.2011.05.017
doi:10.1016/j.foreco.2009.07.039

Examples on Eucalypt plantations

- Growth potential

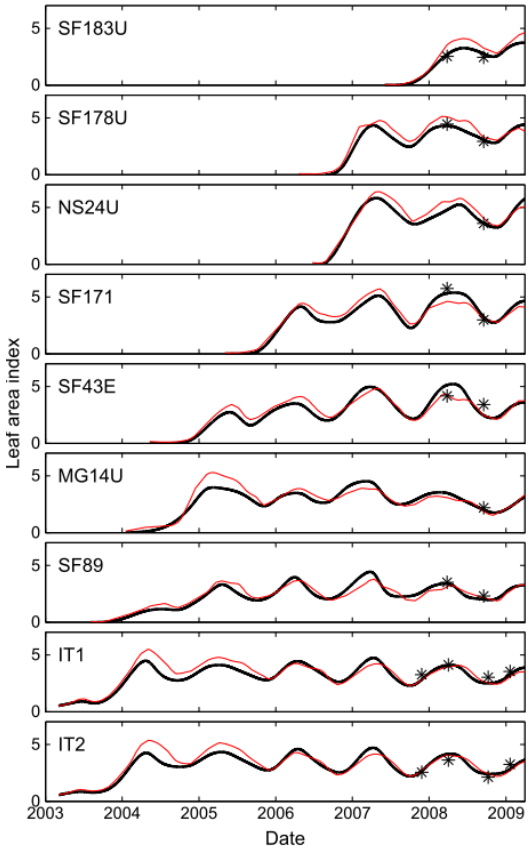


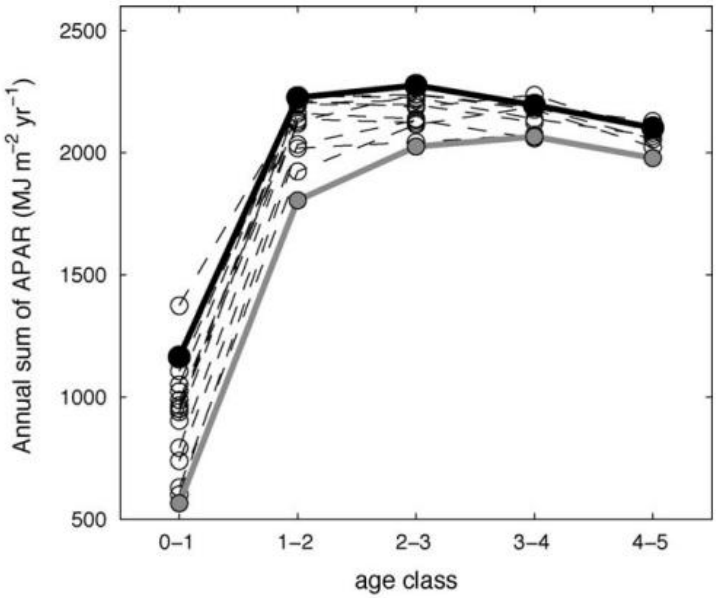


Marsden et al. 2010, Forest Ecology and Management
doi:10.1016/j.foreco.2009.07.039

Examples on Eucalypt plantations

- Leaf area index, APAR





Le Maire et al., 2011, Remote sensing of Environment
http://dx.doi.org/10.1016/j.rse.2010.10.004

Taking forest plantation to the space age !

- What are the needs ? **Production**
  - Inventory (biomass)
  - Growing conditions and health (short and long terms) : multi-indicator
  - Rapid analyze for rapid response
  - Intra-stand variability (precision forestry)
  - Field portable solutions (device with up-to-date image, etc.)

Taking forest plantation to the space age !

- What are the needs ? **Environmental**
  - **Water cycle**: EO can improve the models at the scale of the stand or the watershed, recycling in atmosphere vs. soil recharge
  - **Carbon cycle**: EO data assimilation into models for carbon sequestration estimation, standing biomass stocks
  - Monitoring the **preservation areas**: biomass growth, biodiversity,…

Taking forest plantation to the space age !

- **New satellites offer new opportunities:**

Tendency: higher spatial and temporal resolution, higher quality, free access, dedicated EO sensors

  - Venμs (research) : 2 days, 5 m resolution, many spectral bands
  - Sentinel (currently, long continuity project): probably the most promising: radar, optical and thermal, high resolution, high revisit, free !
  - Biomass satellite (2020)
  - FLEX (2022)

- **New approaches:**
  - Synergy between sensors (EO, meteo, etc.)
  - Automatic production of higher level products
  - Machine learning, big data
  - Data assimilation in process-based forest models

Taking forest plantation to the space age !

- As a conclusion : Next steps…
  - Test the different possibilities with *in situ* validation, and focus on the more promising ones
  - **Need of field measurements**: highly instrumented site like the EUCFLUX project, stand networks with dedicated measurements, valorisation of company GIS, etc.
  - Need of parallel **progress in process-based ecophysiological modelling** of stand functionning for understanding the EO signal
  - **Need for research cooperation programs** for developing methods adapted to new satellites

Thank you !

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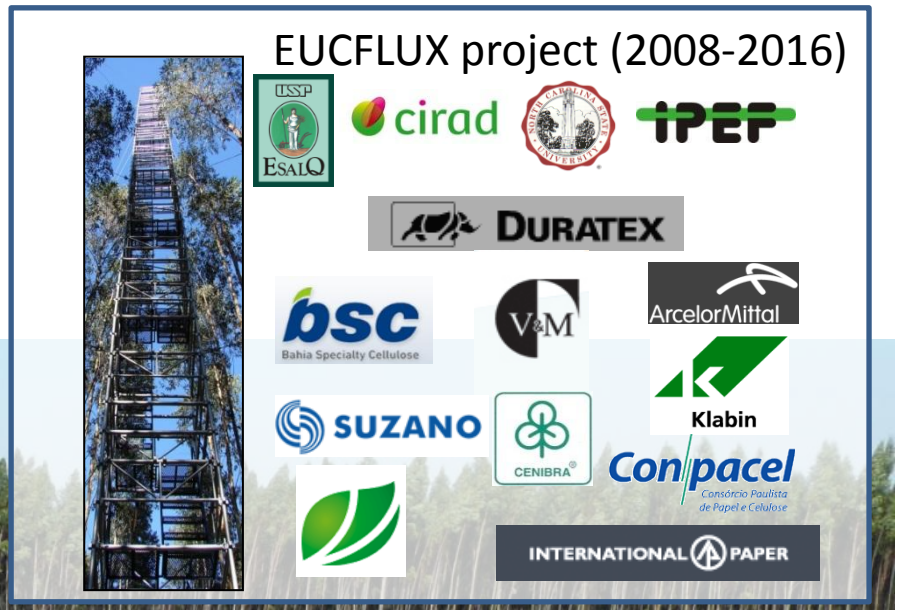

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