FOREST NPP AND VOLUME GROWTH IN FINLAND INFERRED FROM CLIMATE AND SATELLITE DATA

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INTRODUCTION
BACKGROUND

- **Short-term Monitoring**
  - Forest inventory
  - Empirical
  - Process-based
  - Climate & soil
  - DGVM

- **Long-term**
  - Productivity of actual vegetation in historical climate
  - Productivity of actual vegetation in actual climate
  - Potential vegetation and productivity in actual climate
BACKGROUND

- Advances in remote sensing technology => should be applied to its full capacity for forest monitoring (Reiche et al. 2016)
- Progress in
  - Land cover
  - Species distribution (Immitzer et al. 2012, 2016)
  - Above-ground biomass (Balzer et al. 2003, Zaki and Latif 2017, ref.)

Nature CC 2016

COMMENTARY:

Combining satellite data for better tropical forest monitoring


Implementation of policies to reduce forest loss challenges the Earth observation community to improve forest monitoring. An important avenue for progress is the use of new satellite missions and the combining of optical and synthetic aperture radar sensor data.
BACKGROUND

- LAI and PAR radiation
  - GPP (NPP) e.g. MODIS algorithm
    (Running et al. 2004)

- What about
  - CUE
  - Volume growth

- Depend on forest stock not just LAI
  (e.g. Collalti et al. 2020 GCB)
OBJECTIVE

• Use satellite products to
  • Estimate forest variables
  • Assess current C fluxes and volume growth
• Compare use of products with different resolution
• NorthState project EU FP7 2014-2017

http://northstatefp7.eu/
MATERIAL AND METHODS
C FLUXES FROM GROUND-BASED DATA

PREBAS
VALENTINE & MÄKELÄ 2005 TP
C FLUXES FROM GROUND-BASED DATA

Multi-source inventory data

Gridded Weather data

Growth rate

PREBAS
MINUNNO ET AL. 2019 ForEco

Mean annual growth in forestry regions

\[ y = 1.0258x \]

\[ R^2 = 0.9558 \]

Statistics (m$^3$ ha$^{-1}$ yr$^{-1}$)

Model (m$^3$ ha$^{-1}$ yr$^{-1}$)

HOLMBERG ET AL. 2019 FRONTIERS IN PLANT SC
METHOD

A. Forest variable prediction from satellite images

1. Suomi NPP reflectance image mosaic
2. LAI computation
3. Reference data
4. Model computation
5. Prediction
6. Post processing
7. External masks

B. Carbon flux prediction from forest variables and climate data

1. Climate inputs
2. LAI inputs
3. Site BA, H, V inputs
4. CROBAS
5. Tree carbon stock
6. Yasso
7. Soil organic matter
8. Respiration
9. Litterfall & decay
10. Woody debris

References:
MATERIAL

• Prediction data
  • Suomi-NPP
    – Finland wall-to-wall
    – Resolution 500 x 500 m
    – > 200 images May – Sep 2016
  • Sentinel 2
    – Hyytiälä, Sodankylä
    – Resolution 10 x 10 m
    – 79 images summer 2016
MATERIAL

• Reference data
  Suomi-NPP
  – Luke thematic maps, average 500x500m
  Sentinel 2
  – Ground data from National Board of Forests

• Test data
  – Samples from Very High Resolution data
  – Forest statistics; part of training data set

• Climate data
  – FMI gridded data 1 km x 1 km 1980 – 2010
  – PAR, T, P, VPD daily
RESULTS: FOREST VARIABLES
Forest variables
Suomi NPP
Sentinel-2
LAND TYPE ACCURACY, SUOMI NPP

Forest area

Site type

VHR median
land cover map

Herb rich    Mesic    Xeric
TREE VARIABLE ACCURACY, SUOMI NPP

Stem volume

Tree height
TREE VARIABLE ACCURACY, SENTINEL 2

Comparison with NFI in forestry districts
RESULTS: C FLUXES
Sentinel 2

NPP

Current Annual Increment

Net Primary Productivity
Hyytiälä - Finland (2016)
Map area: 100 km x 100 km

Mean Annual Increment
Hyytiälä - Finland (2016)
Map area: 100 km x 100 km

Value
High : 700
Low : 0
Open Peat
Aralbe
Water
Artificial
No data

MAI [m³/ha/a]
High : 12
Low : 0
Open Peat
Aralbe
Water
Artificial
No data

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Suomi NPP  Sentinel-2
MEAN ANNUAL GROWTH IN FORESTRY REGIONS: SUOMI NPP

- Small bias
- Poor accuracy
MEAN ANNUAL GROWTH IN FORESTRY REGIONS: SENTINEL-2
MEAN ANNUAL GROWTH IN FORESTRY REGIONS: SENTINEL-2

Mean annual growth in forestry regions

Statistics (m$^3$ ha$^{-1}$ yr$^{-1}$)

Model (m$^3$ ha$^{-1}$ yr$^{-1}$)

Mean annual growth in forestry regions:

- South
- North-East
DISCUSSION & CONCLUSIONS

• Growth rate predictions are sensitive to initial state and site type
• Best accuracy does not necessarily lead to best predictions
  • Scale issues
• Ongoing research to improve results (ESA)
  • Forest variable estimation
  • Contribution of soil carbon => NEE
  • Detection of change in forest cover
  • European boreal region
THANK YOU FOR YOUR ATTENTION!
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