belspo
STEREO III

STR3S

Can satellite-observed fluorescence be used to map transpiration?

Diego Miralles [1,2], Wouter Maes [3,2], Niko Verhoest [2], Kathy Steppe [3], Wouter Dorigo [4,2], Pierre Gentine [5]

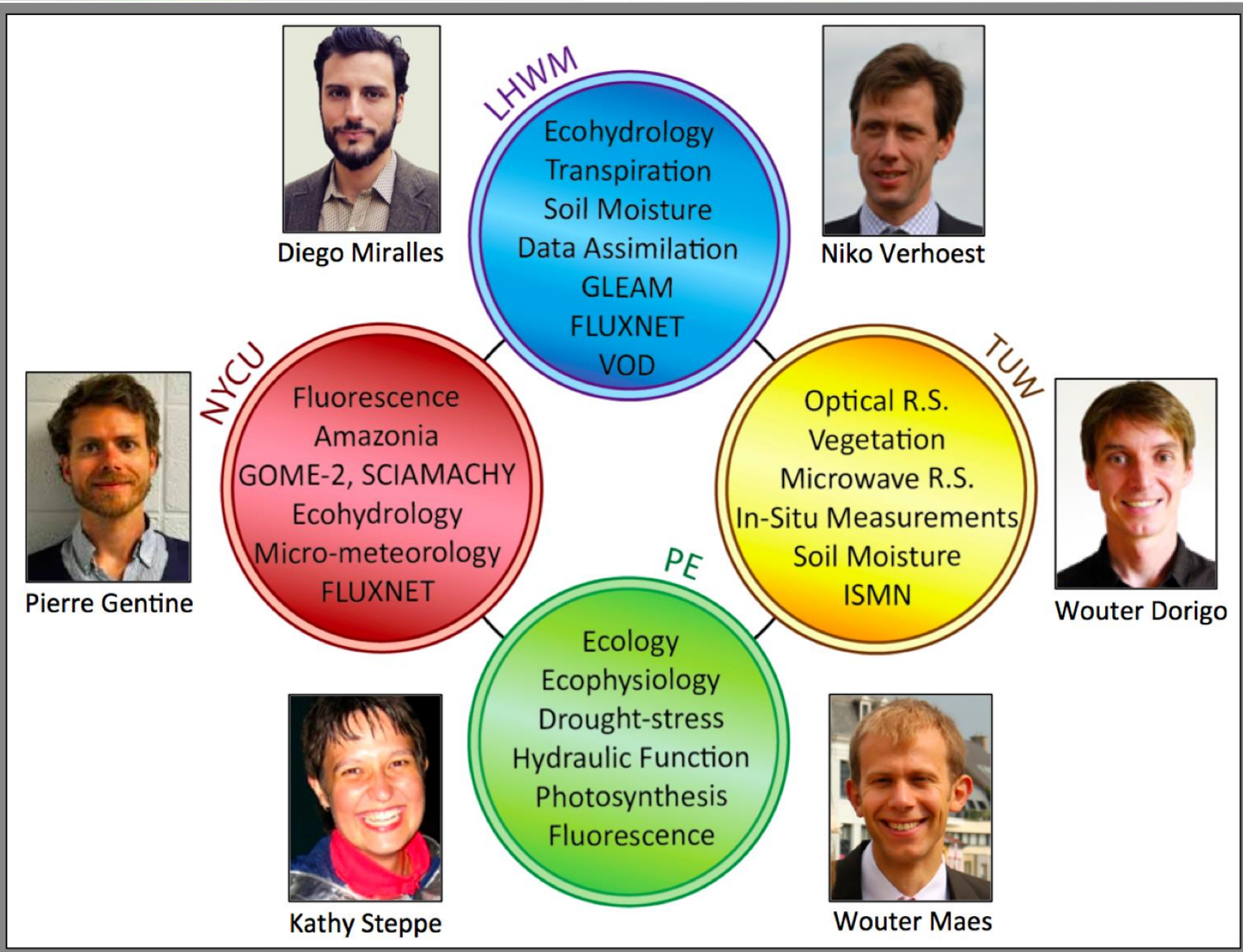
[1] Department of Earth Sciences – VU Amsterdam University
[2] Laboratory of Hydrology and Water Management – Ghent University
[3] Laboratory of Plant Ecology – Ghent University
[4] Department of Geodesy and Geoinformation – Vienna University of Technology
[5] Department of Earth and Environmental Engineering – Columbia University New York

BEODAY, 08/12/2016

GHENT UNIVERSITY

TU WIEN TECHNISCHE UNIVERSITÄT WIEN

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK


LHWM
Ecohydrology
Transpiration
Soil Moisture
Data Assimilation
GLEAM
FLUXNET
VOD
NYCU
Fluorescence
Amazonia
GOME-2, SCIAMACHY
Ecohydrology
Micro-meteorology
FLUXNET
TUW
Optical R.S.
Vegetation
Microwave R.S.
In-Situ Measurements
Soil Moisture
ISMN
PE
Ecology
Ecophysiology
Drought-stress
Hydraulic Function
Photosynthesis
Fluorescence
Diego Miralles
Niko Verhoest
Pierre Gentine
Wouter Dorigo
Kathy Steppe
Wouter Maes

...why transpiration?

① **Crucial for water management**: ~2/3 of land precipitation evaporated. Transpiration > runoff !

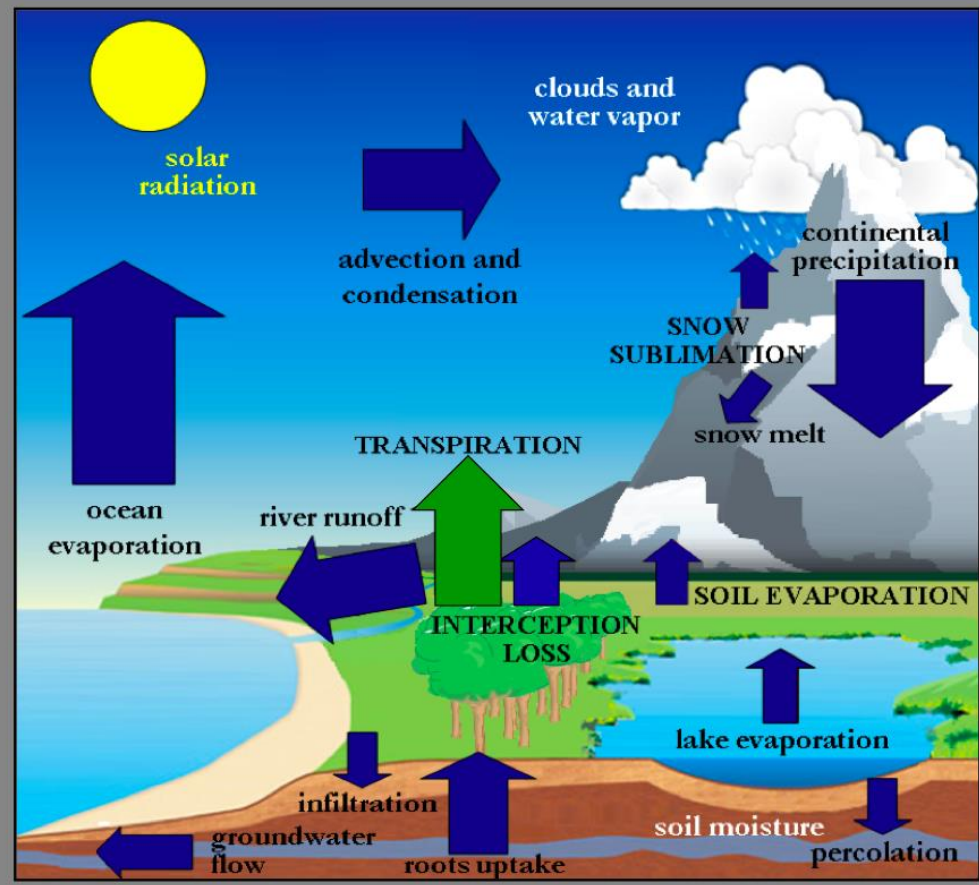
② **Crucial for climate**: reacts to climate change and also feeds back on climate

③ **Crucial for society:** driver of droughts and heatwaves, and required for agriculture

Poorly understood globally: scarcity of *in situ* measurements and inability to observe from satellite

but...

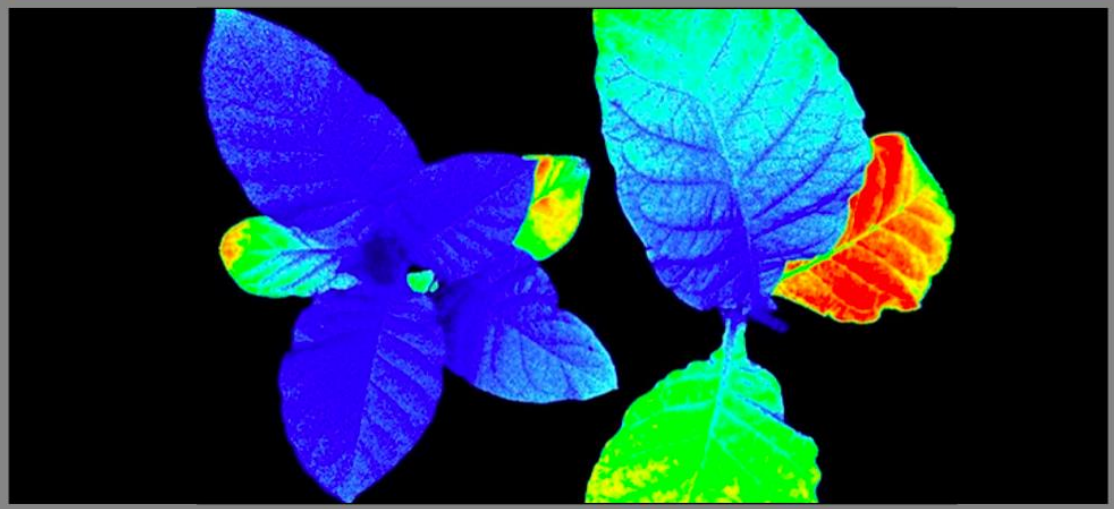
transpiration and photosynthesis are synchronized: they occur simultaneously and share the same bio-physical drivers

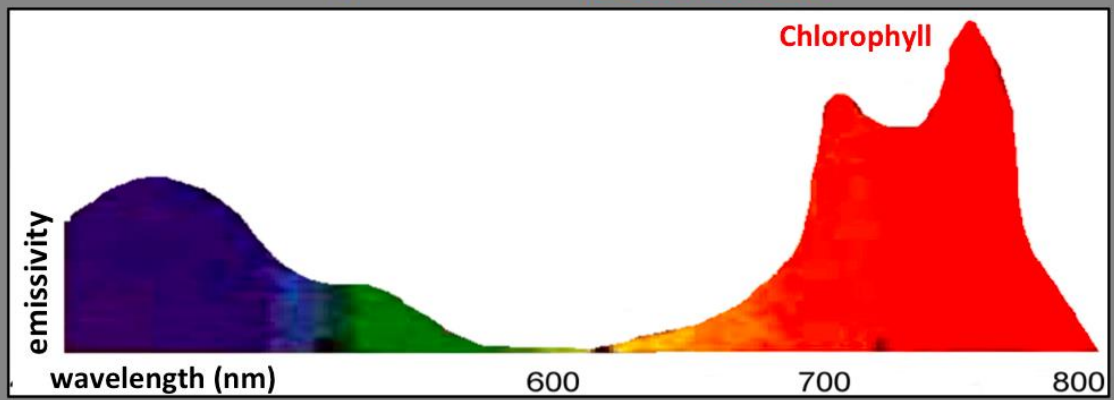


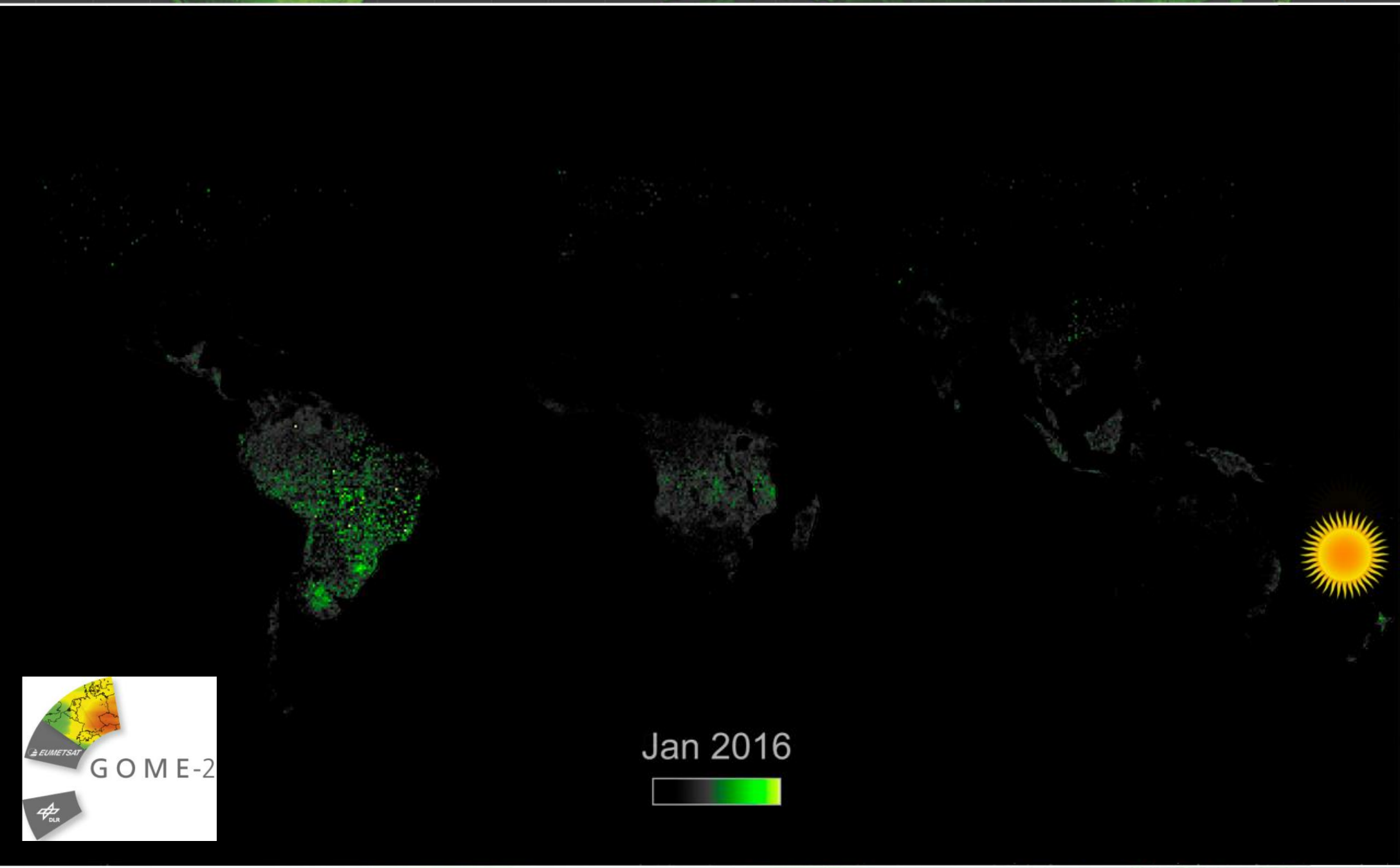
...can we observe photosynthesis instead?

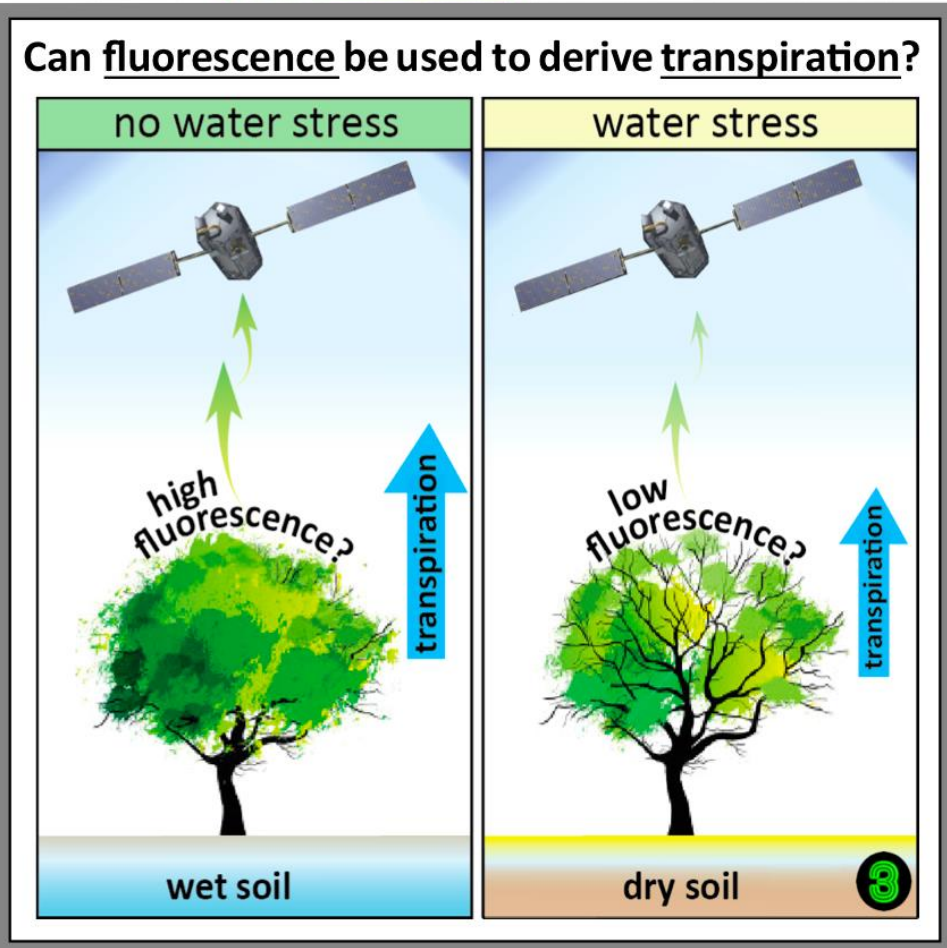
- **Plants glow when they photosynthesize**
- That subtle glow is referred to as solar-induced **fluorescence** (SIF) and it can be measured *in situ*, and now **also from space**...

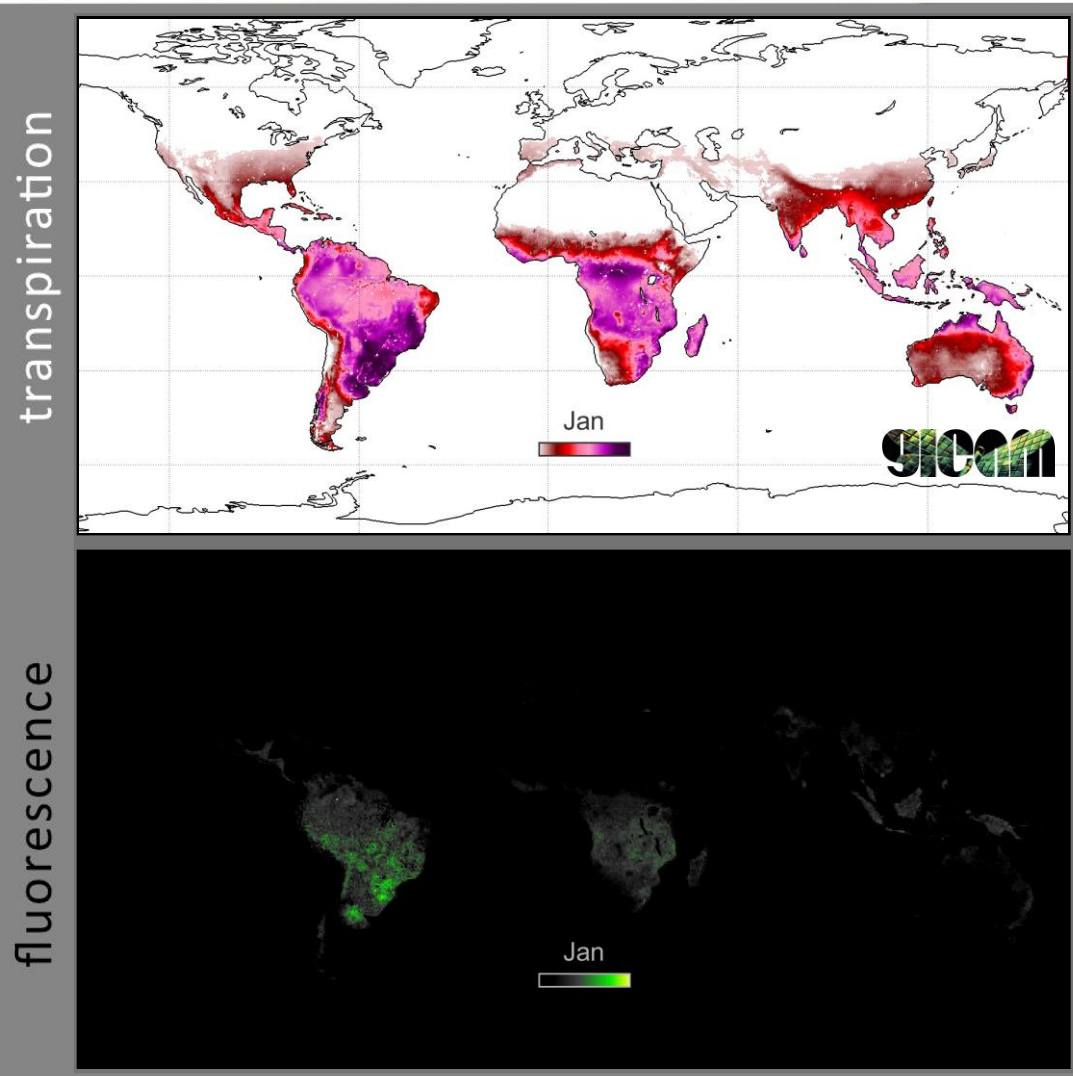
- **New sensors like GOME-2, OCO-2, TROPOMI,** SCIAMACHY and GOSAT **sense fluorescence globally** at increasingly higher resolution
- Upcoming dedicated **ESA FLEX mission**






Jan 2016
EUMETSAT
GOME-2
DLR





STR3S OBJECTIVES

① To conform a **dataset of vegetation stress from fluorescence** and learn about its dynamics

② To conform a **dataset of transpiration** by incorporating the vegetation stress into GLEAM, and use it to gain understanding into the variability of the global water cycle

Soil Module

Multi-layer bucket model driven by satellite precipitation and surface soil moisture

root-zone soil moisture

Evaporation Module

Priestley and Taylor eq. driven by satellite-observed meteorology

potential transpiration, T_p

Stress Module

Semi-empirical relationship to root-zone soil moisture and VOD

stress factor, S [0–1]

stress factor, $S = f(F)$?

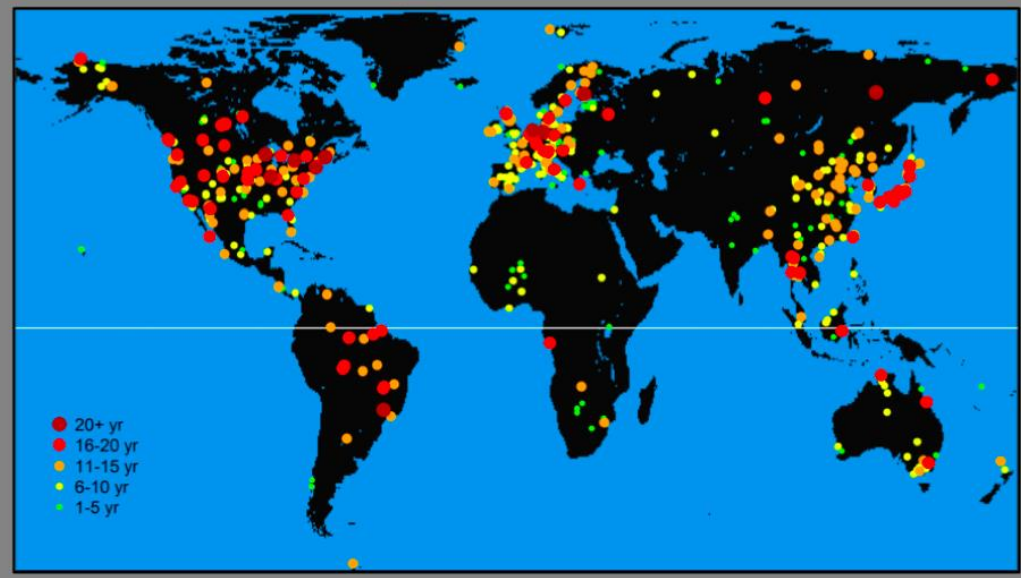
transpiration, $T = T_p \times S$

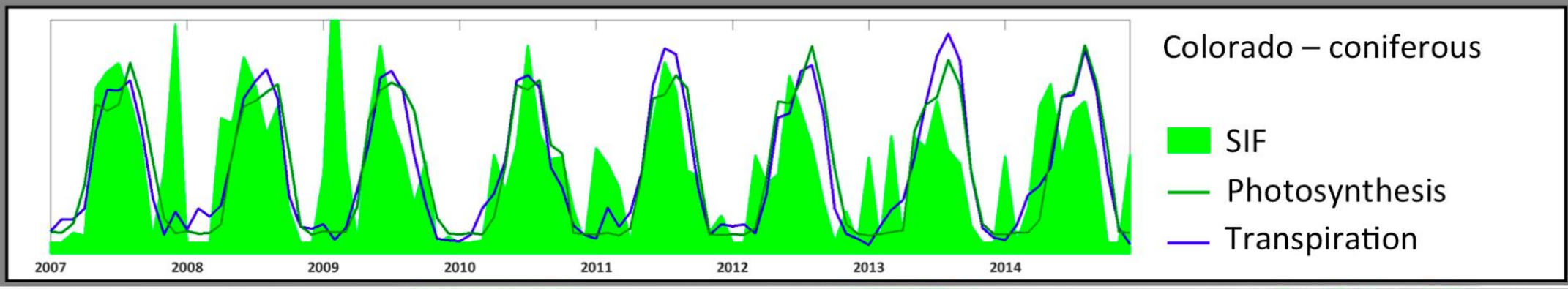
El Niño–La Niña cycle and recent trends in continental evaporation
Miralles *et al.* 2014

nature climate change

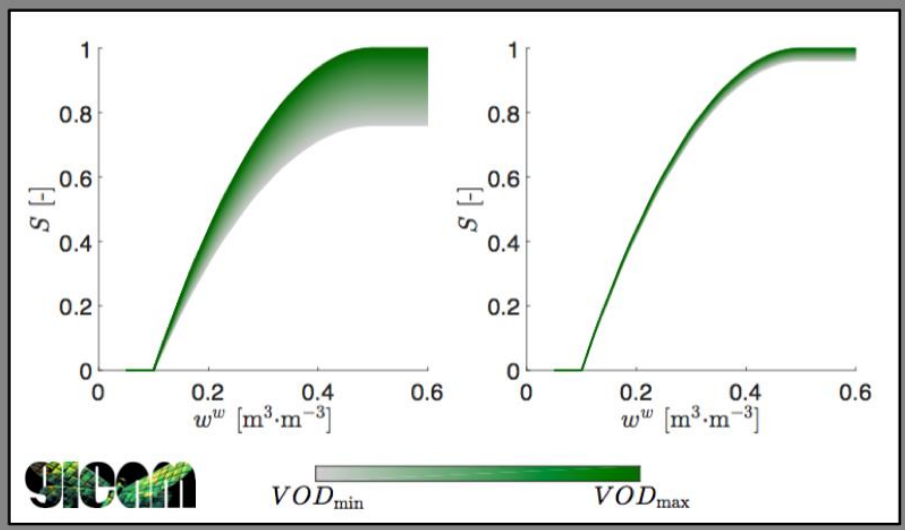
FLUXNET – A Global Network

FLUXNET 2015 – Database



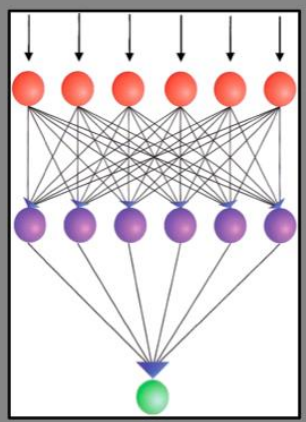


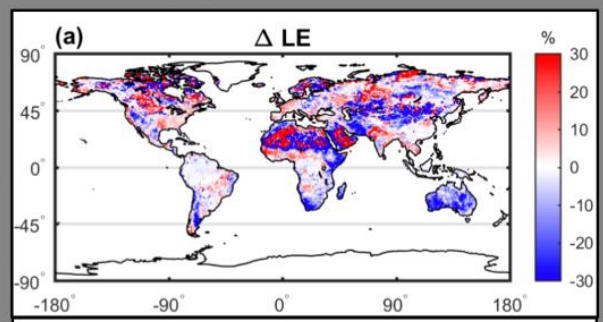
Process-based approach



Data-driven approach

ANN





Biogeosciences Discussions
Open Access
EGU

Biogeosciences Discuss., doi:10.5194/bg-2016-495, 2016
Manuscript under review for journal Biogeosciences
Published: 18 November 2016

① **Two-year project** with the **novel goal of using satellite fluorescence** to improve understanding of **global water cycle dynamics**

② Based on incorporating fluorescence into an **existing global transpiration model**, but also exploration of data-driven methods

③ Implications for **climate modeling: accurate transpiration** needed for **better temperature projections**

④ Right timing: anticipating to **ESA FLEX fluorescence mission**

STR3S.org

STR3S

HOME RATIONALE OBJECTIVES TEAM DATA MODEL NEWS

Stress on TRanspiration
Sensed from Satellite
Systems