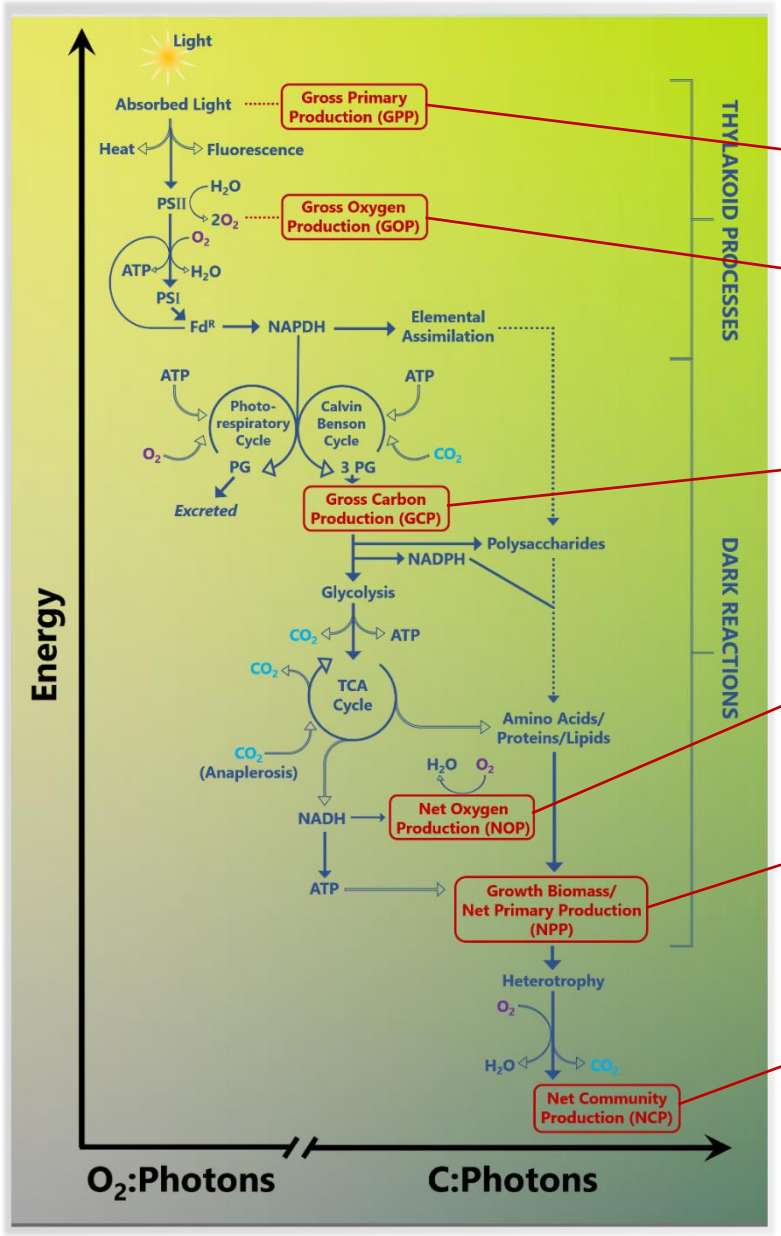
Towards Reconciling Uncertainty in Oceanic Primary Productivity from Sea to Space

Ryan Vandermeulen[1,2], Toby Westberry[3], Joaquín Chaves[1,2], Aimee Neeley[1,2], Ivona Cetinić[1,4], Emily Smith[5]

[1]NASA Goddard Space Flight Center, Greenbelt MD, USA
[2]Science Systems and Applications, Inc., Lanham MD, USA
[3]Oregon State University, Corvallis, OR, USA
[4]Morgan State University, Baltimore MD, USA
[5]National Oceanic and Atmospheric Administration, Silver Spring MD, USA

Aquatic Primary Productivity Continuum



Adapted from Halsey, Letelier, Vandermeulen (2022)

Measurements of primary production aim to assess the rate at which energy or carbon is captured in the aquatic system

GPP: the rate of light energy absorption by the algal community.

GOP: the rate of energy (electrons) captured through the light-harvesting reactions of photosynthesis .

GCP: rate at which CO_2 is converted into organic carbon by the Calvin Benson cycle (70-75% of GOP due to O_2 reduction).

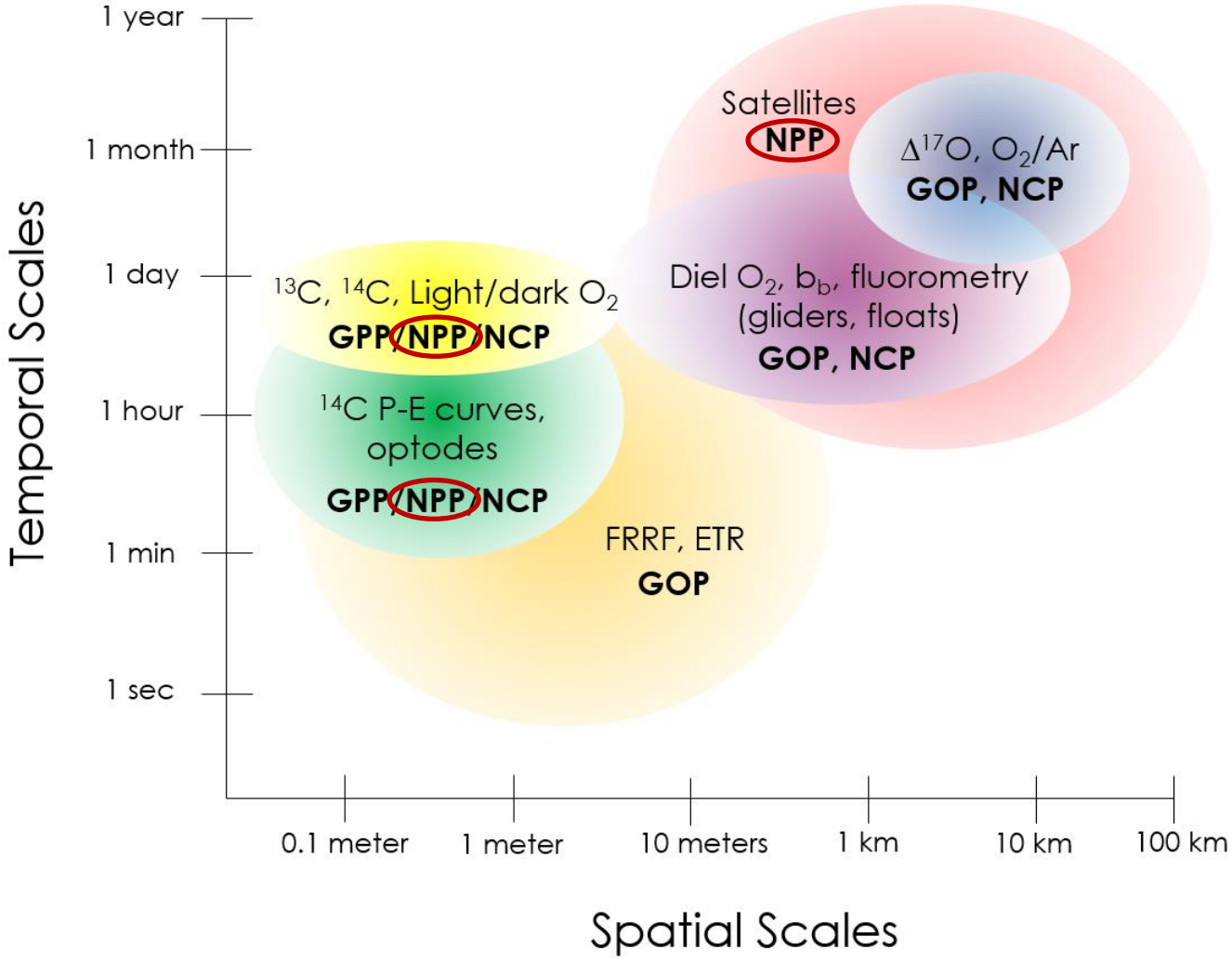
NOP: amount of O_2 produced after accounting for all O_2 reduced by respiration (organic carbon → chemical energy).

NPP: rate of organic carbon production after accounting for subcellular carbon catabolism (e.g. biosynthesis, cell division, DNA replication) and respiration.

NCP: rate of carbon production that escapes degradation by the surface microbial community and is thus available for export into the twilight zone.

Time and Space

- Each method elucidates distinct processes that contribute to a holistic and integrated characterization of aquatic microbial energy and carbon dynamics on Earth.
- Normalizing a variety of emerging technologies, can improve our simultaneous understanding of larger scale spatial-temporal dynamics as well as smaller scale cell physiology, which are intrinsically linked.



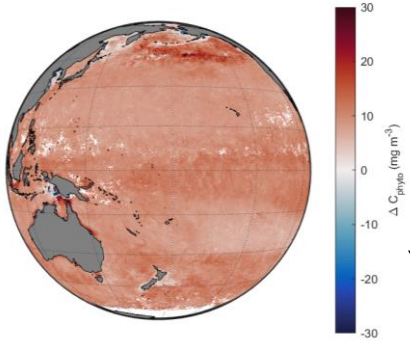
An "End to End" validation of PP requires the quantitative assessment of inputs, intermediates, and outputs to understand and (better) constrain model uncertainties.

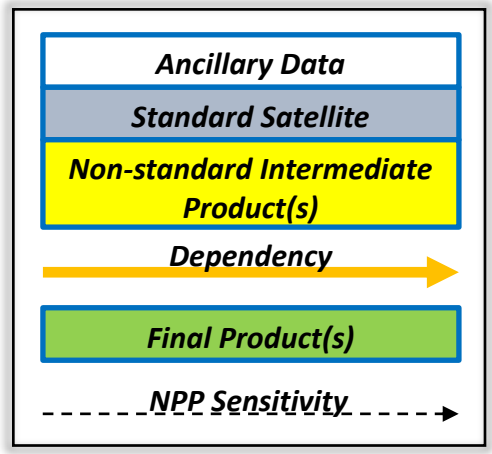
E_k parametrized ± 10%
±3.65 Pg C y^{-1}
7.0% difference

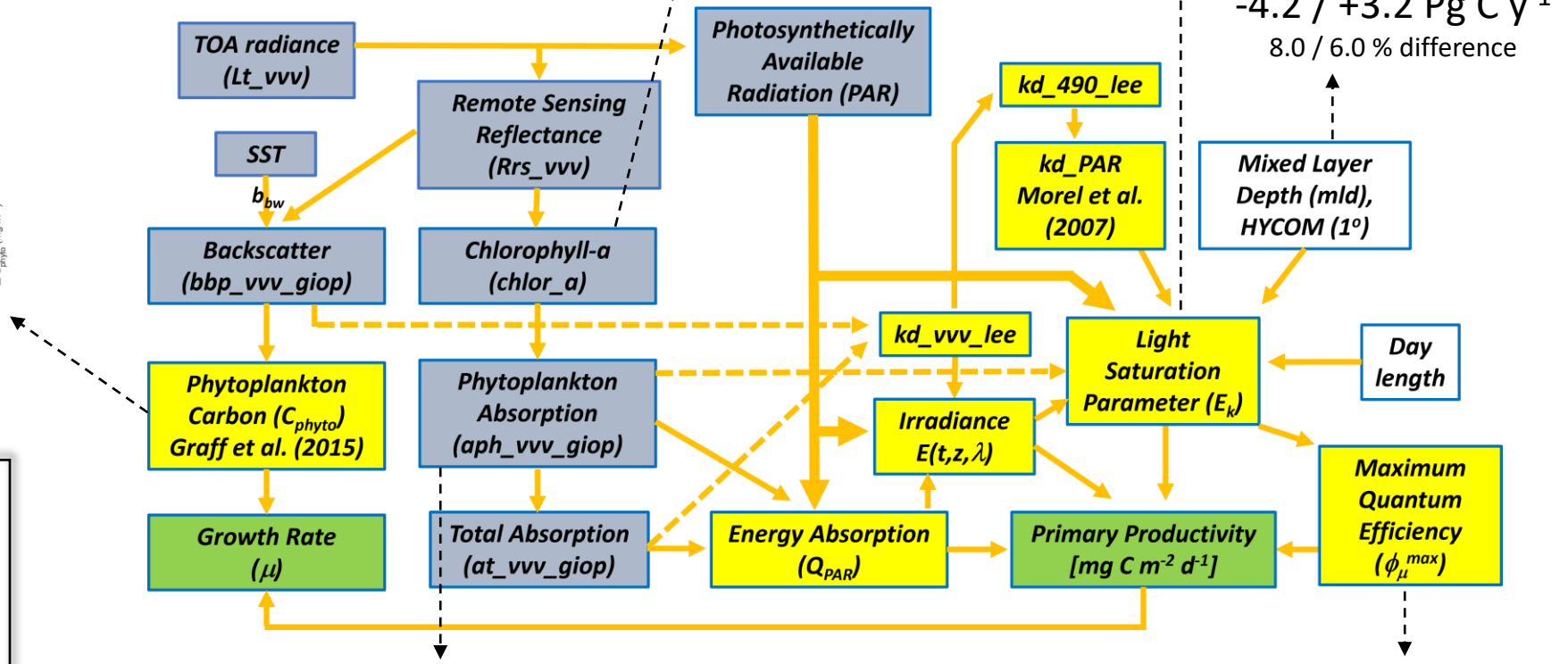
a_ϕ magnitude constrained by chl-a
+2.45 Pg C y^{-1}
4.7% difference

Parameterization of subsurface a_ϕ
-4.2 / +3.2 Pg C y^{-1}
8.0 / 6.0 % difference

C_{phyto} - (GIOP v. GSM)
-9.8 mg C m^{-3}
38% difference







+4.8 / -5.7 Pg C y^{-1}
9.2% / 11% difference

Using SST model to derive ϕ_μ^{max}
-1.11 Pg C y^{-1}
2.1% difference

Web of dependencies

(values adapted from Silsbe et al. 2016)

https://doi.org/10.1002/2016GB005521

Knowledge Gaps and Priorities

1 year timescale

- Assess satellite product uncertainty requirements for existing/future aquatic PP models
- Integration of aquatic PP continuum into validation stream (NASA/IOCCG protocols)

5 year timescale

- GAP: “End-to-end” validation for PP models
- PPARR (round robin) activity, including inherent/apparent optical properties, variable fluorescence.

10 year timescale

- Global network of BGC-ARGO (w/ radiometry) for calibrating/validating Aquatic PP models
- Development of PP model(s) that are analytically considerate of the entire PP continuum (GPP→NCP).