Exploitation of CCI products in the second Regional Carbon Cycle Assessment and Processes (RECCAP-2)

ESA CMUG meeting

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Exeter, UK

Goals of RECCAP-2

- To establish the mean carbon balance of large regions, their trends and inter-annual variability, including their component fluxes, consistent with global carbon budgets.

- To do it by comparing and reconciling multiple bottom-up estimates (e.g. land surface models) with the results of top-down atmospheric inversions, with attribution to main flux components.

- To evaluate the regional 'hot-spots' of inter-annual variability and possibly the trends and underlying processes over the past two (or more) decades by combining available long-term observations and modeling.

Project overview

Teams and workplan

September each year → GLOBAL CARBON project

LSCE · futurearth research for global sustainability

LSCE (Laboratoire des Sciences du Climat & de l'Environnement) – Atmospheric CO_2 inversions
- Annual updates of global and regional CO_2 budgets & uncertainties (CAMS, CarboScope, CarbonTracker)
- Comparison of in-situ based and satellite CCI GHG based budgets
- Analysis of global and regional inter-annual anomalies and drivers

University of Exeter – Land surface models (LSMs)
- Annual update of LSMs' outputs (GPP, TER, NEE, LAI, C-stocks, etc) for globe and RECCAP regions
- Evaluation of LSMs against ESA-CCI products (burned-area, biomass, land-cover, soil-moisture)
- Analysis of LSMs ability to capture inter-annual variability and extremes (e.g. ENSO)

Max Planck Institute for Biogeochemistry – Data-driven* models (* ESA-CCI & EO data)
- Annual production of data-driver estimates of GPP, TER, NEE since 1982
- Uncertainties and biases of data-driven estimates
- Systematic synthesis of uncertainty (predictors, algorithms, network)

Synthesis of top-down and bottom-up estimates

Experiment plans for working with CCI+ ECV data

CCI + GHG

- ‘Standard’ set of atmospheric CO2 inversions: based on in situ observations
- Also investigate inversions based on XCO_2 from GOSAT satellite (2009-present)

→ Complement to GHG-CCI+ team that should address more recent satellites (OCO-2, TanSat, and GOSAT-2)

Experiment plans for working with CCI+ ECV data

Evaluation of land-surface models

CCI+ Fire

Modelled Burned Area Data / Fire size

CCI+ Soil Moisture

Modelled soil moisture

CCI+ Biomass

Above groud biomass C-stocks

CCI+ Land Cover

Distribution of forest area

LULCC

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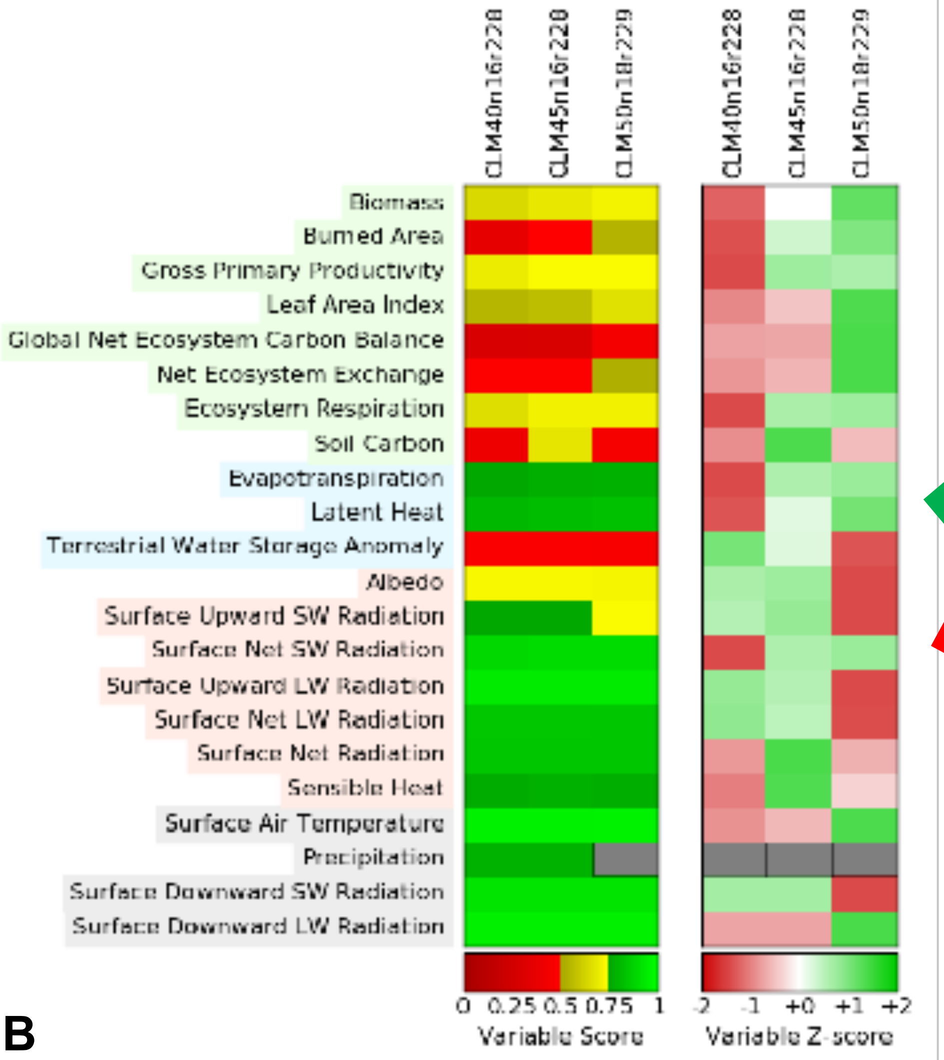
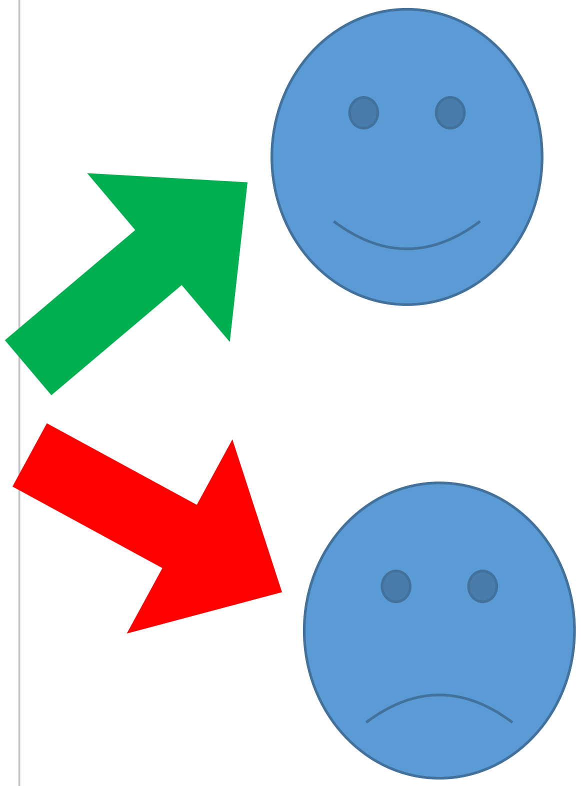
Distribution of forest area
LULCC





→ **Integration in the International Land Models Benchmarking programme ILAMB (https://www.ilamb.org)**

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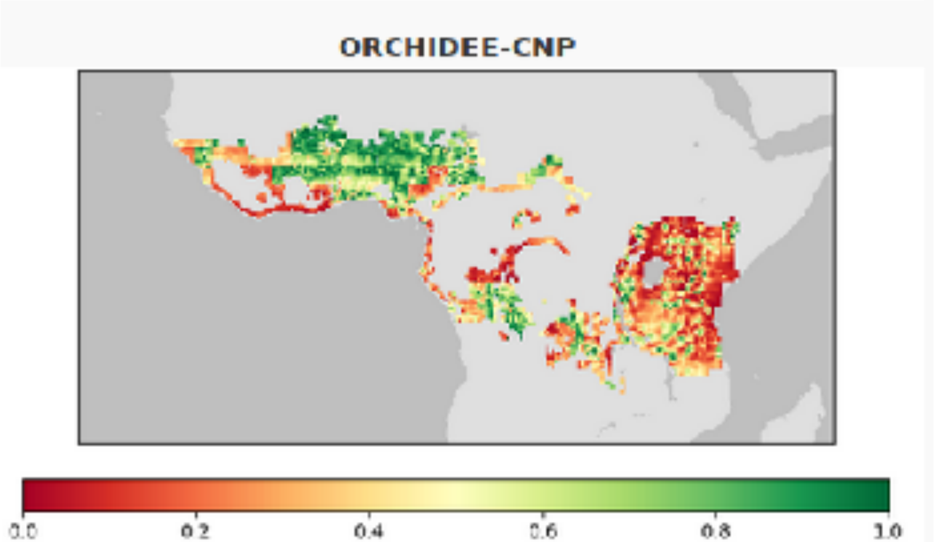
Preliminary **results using CCI+ Soil Moisture**

Global scores:
Bias
RMSE
Seasonality
Spatial distribution
IAV

	Download Data	Period Mean (original grids) [	Model Period Mean (intersec	Model Period Mean (complem	Benchmark Period Mean (inte	Benchmark Period Mean (con	Bias [kg m-2]	RMSE [kg m-2]	Phase Shift [months]	Bias Score [1]	RMSE Score [1]	Seasonal Cycle Score [1]	Spatial Distribution S	Interannual V	Overal
Benchmark	[-]	3.76													
CLM5.0	[-]	10.8	9.63	13.4	3.76	4.31	5.87	6.03	1.29	0.017	0.27	0.82	0.44	0.43	0.37
ISAM	[-]	6.08	6.05	5.66	3.75	4.76	2.29	2.50	1.28	0.18	0.44	0.82	0.72	0.75	0.56
JSBACH	[-]	15.4	16.2	15.5	3.72	4.41	12.5	12.7	1.28	0.0011	0.13	0.82	0.24	0.25	0.26
JULES	[-]	11.3	10.7	12.2	3.76	4.63	6.96	7.06	1.39	0.0055	0.28	0.80	0.45	0.48	0.38
LPJ-GUESS	[-]	4.44	4.18	4.64	3.75	4.84	0.428	1.31	1.29	0.37	0.46	0.82	0.93	0.66	0.62
LPX-Bern	[-]	3.24	2.92	3.47	3.76	4.97	-0.832	1.34	1.35	0.37	0.48	0.81	0.92	0.73	0.63
ORCHIDEE-CNP	[-]	4.94	4.66	5.13	3.75	4.34	0.903	1.36	1.38	0.36	0.48	0.80	0.95	0.71	0.63

Grid-level scores:



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Challenges when using observations in RECCAP

Consistency when comparing observed ECVs & climate model data

Global land surface models are perfect « users » of CCI+ data for evaluation purpose.
However, need assumptions and preprocessing for land model output to be constrainable CCI+ data.

- Example: soil moisture in ILAMB

Data gaps

Gaps can limit usefulness in applications.

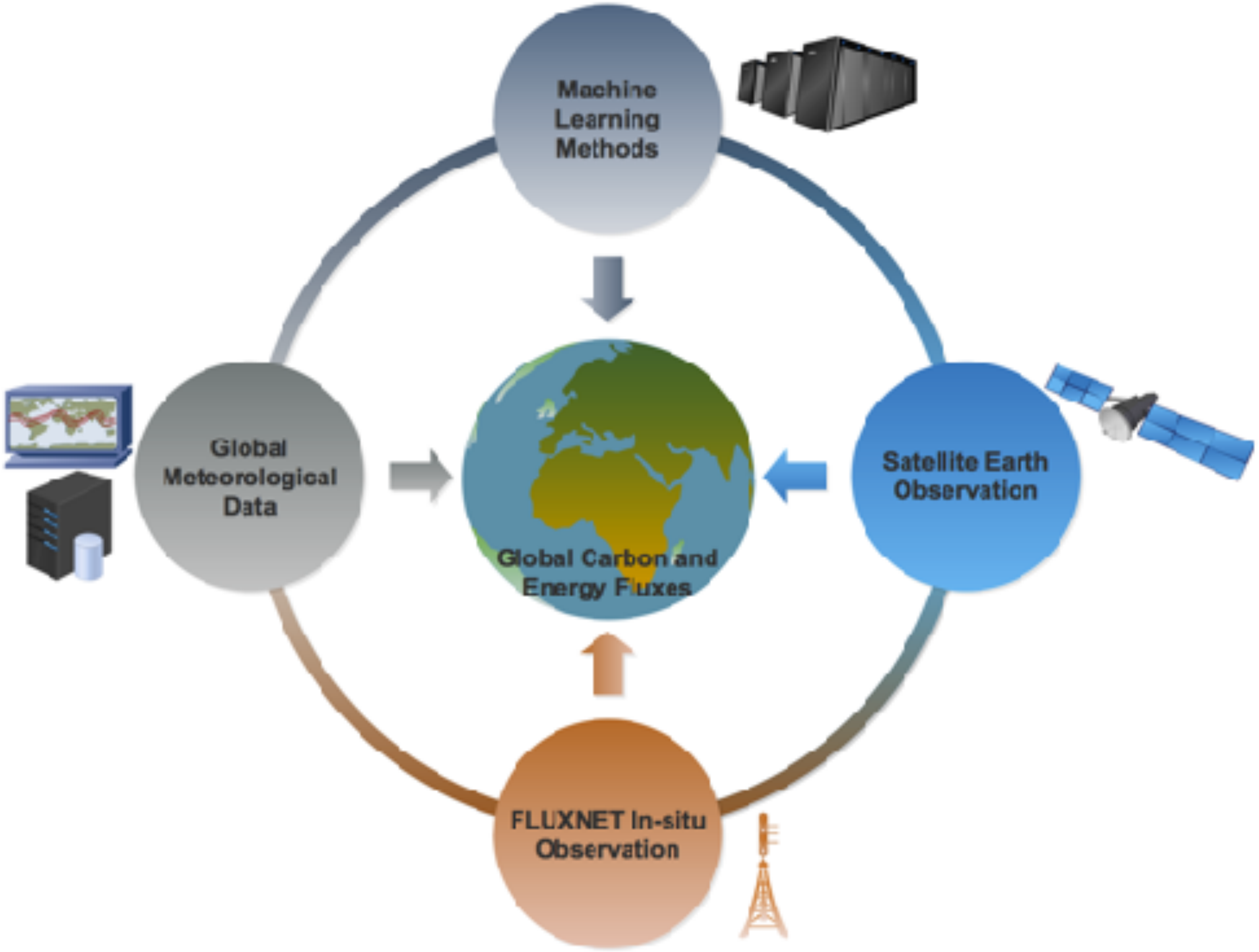
- Example: soil moisture has large spatial gaps in tropics and high latitudes
    - Potential application in data-driven C flux products (FLUXCOM)
    - Potential application as predictor in regressions for the analysis of drivers of land C variability

Climatic drivers of land carbon variability

FLUXCOM dataset

- Includes data-driven estimation of land-atmosphere carbon fluxes
- Input: Climate
  - 'Water availability'
  - Temperature
  - Incoming solar radiation
- Output: carbon-related fluxes
  - Gross primary production
  - Terrestrial ecosystem respiration

Tramontana et al., Biogeosciences (2016)



Climatic drivers of land carbon variability

Identify climatic drivers using regression

Attribute variability in C fluxes to variability in water availability (‘WAI’), Temperature (‘TEMP’), incoming solar radiation (RAD).

- IAV driven by WAI (Humphrey et al., 2018) or TEMP (Jung et al., 2017)?
- Do different regression approaches influence attribution to drivers?
- Influence of ‘land C memory’ and volcanoes?

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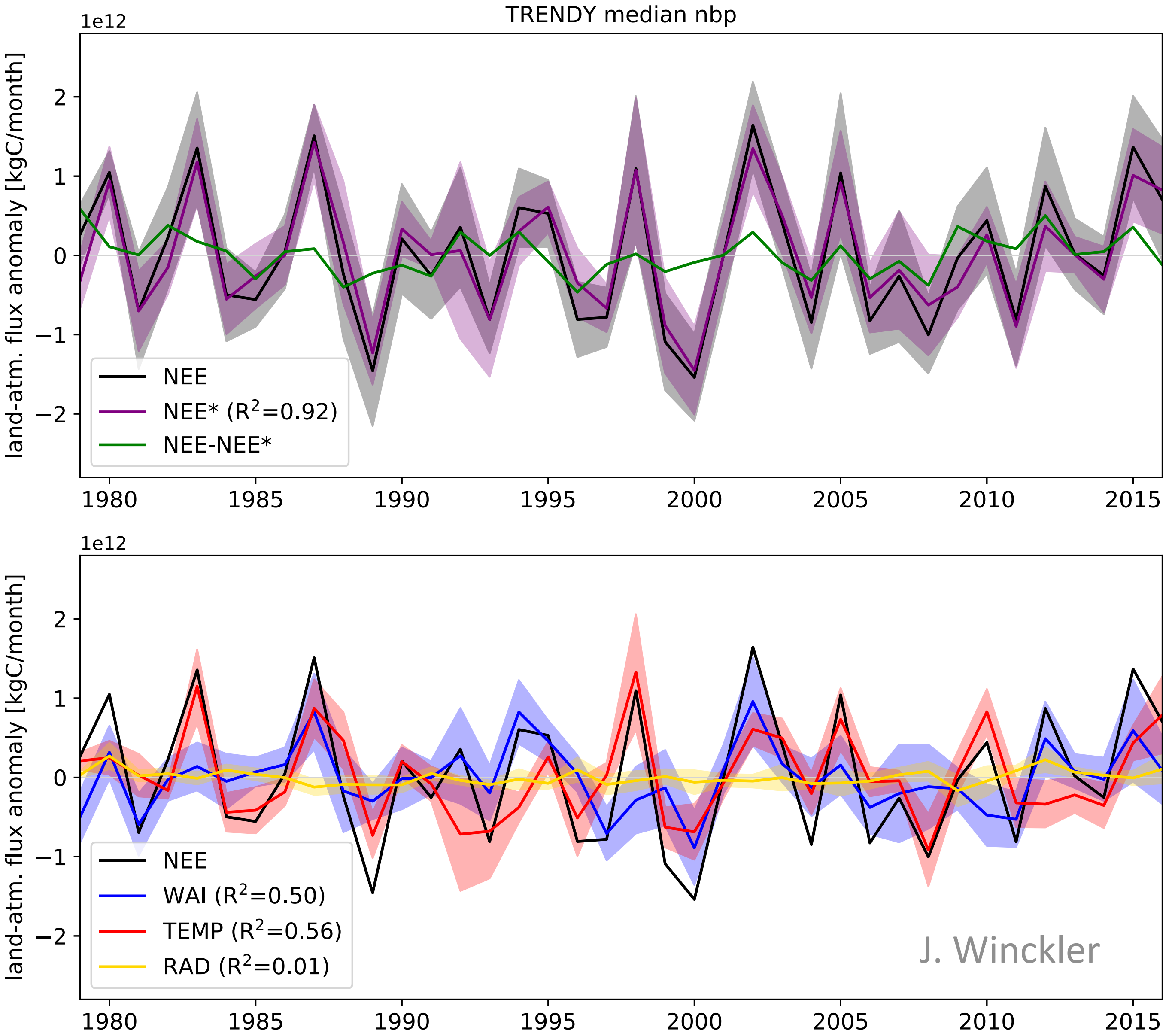

Consistency between ECVs & gaps

Global land surface models are perfect « users » of CCI+ data for evaluation purpose.

However, consistency cannot be achieved because land models have other degrees of freedom / parameters that will not be constrainable even with all relevant CCI+ data.

Uncertainties in products

Wherever possible, reported uncertainties will be used to defined metrics and scores for models.

Uncertainties in the forcing variables (FLUXCOM, inversions) can be used to evaluate uncertainties in the fluxes.

Feedback to ECV teams

Invitation to participate in project meetings
Regular discussion of problems / questions
Presentation of evaluation results and impact of CCI+ data
Participation to ESA meetings (CMUG, Collocation, etc)

ESA-CCI+ and RECCAP-2

1. What are your experiment plans for working with CCI+ ECV data?

2. How will you interact with the relevant teams?

3. How will you address the integrated perspective for consistency between the ECVs, including identification of gaps?

4. How will you use uncertainties in products?

5. What mechanisms will you use to provide feedback to the ECV teams