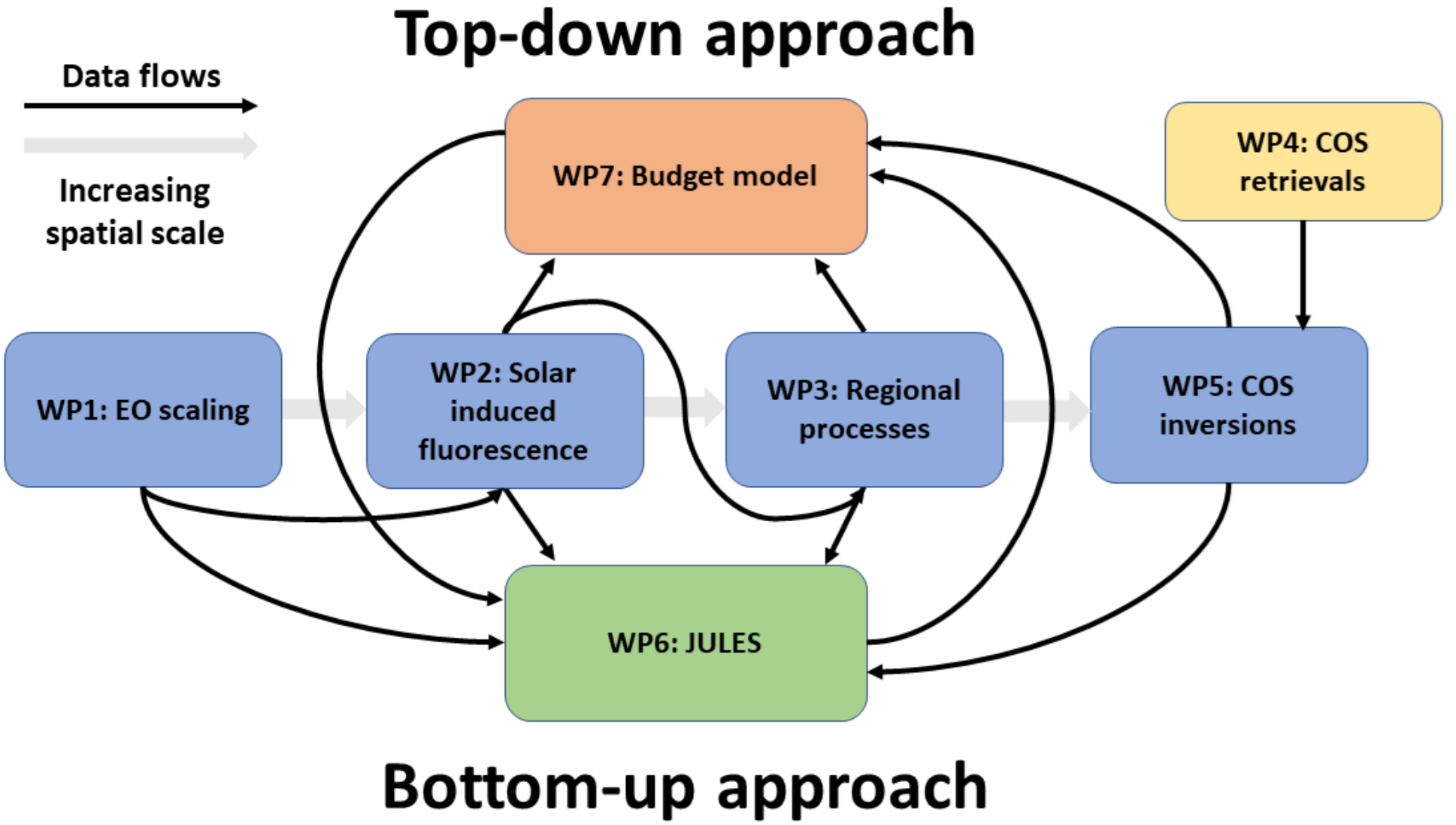
4th Carbon from Space Workshop

Constraining Coupled Carbon & Water Cycle Processes with Earth Observation

Tristan Quaife
25/10/22

A new NCEO research programme

Work package structure

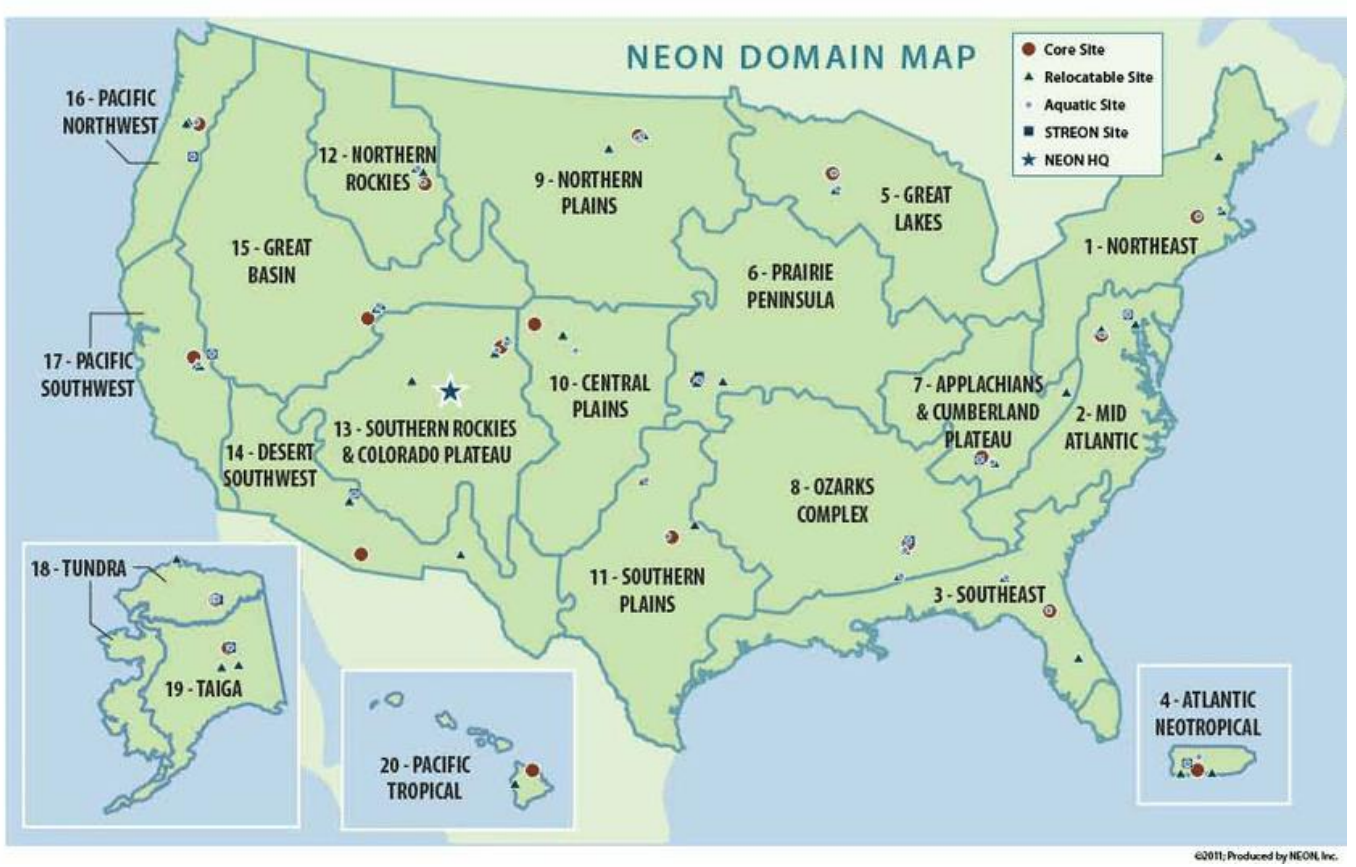


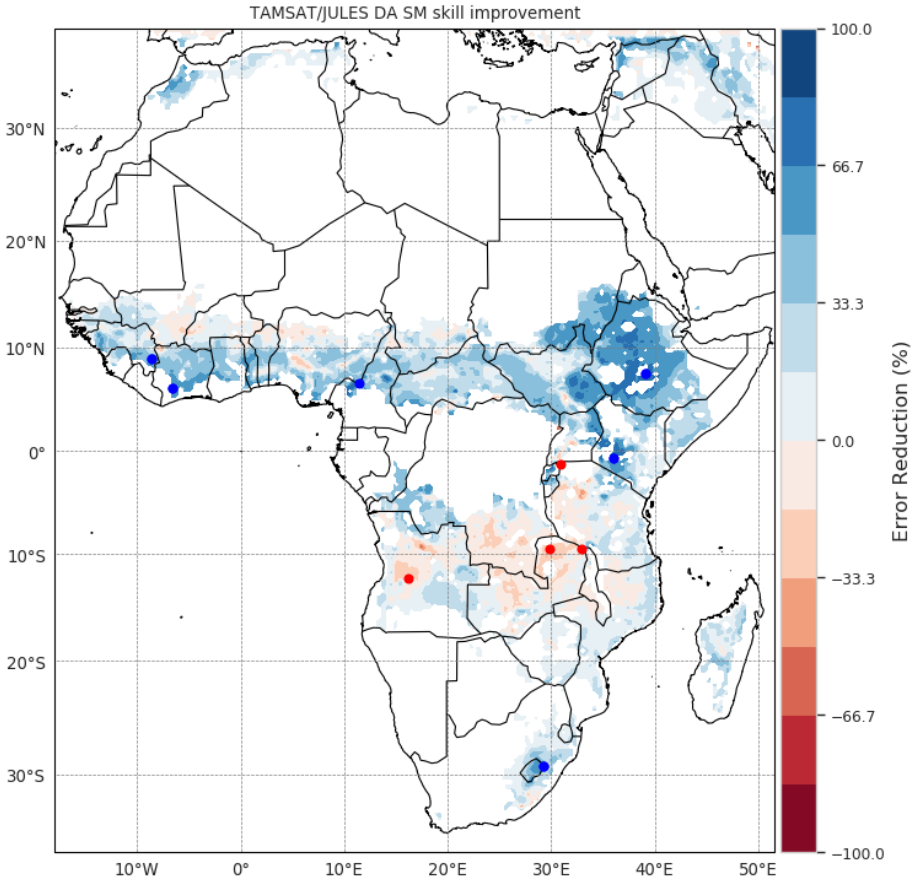
Carbon and water from EO

- Carbon and water are both well observed by EO
- On large scales water controls the carbon cycle
- But the carbon cycle can exert regional controls over the hydrological cycle

B. Dong, K. Haines (U. Reading)

Working at NEON sites & tropical Africa





Main CPEO tasks

- **Develop new EO data sets**
  - Biophysical variables (LAI, leaf chlorophyll, etc)
  - Solar Induced Fluorescence (SIF)
  - Carbonyl Sulfide (COS) inversions
    - Plus corresponding CO_2 fields
- Using these data and others:
  - **Interrogate processes in ESMs**
  - **Assimilate observations** into a bottom-up model (JULES) and a top-down budget model

Biophysical variable retrieval

- Invert canopy radiative transfer models against e.g. Sentinel-2 data
- Using an “archetypes” approach which models plausible growth trajectories
- Focus is on scaling data around NEON sites (including using NEON aircraft data)
- Scaled up variables can then be used to test output of other parts of the programme

Y. Feng, P. Lewis, M. Disney (UCL)

Carbonyl sulfide

- We will deliver **COS atmospheric concentration** data from IASI and **surface flux data** set from INVICAT (inc. CO_2)
- Provides a tracer for GPP: $LRU=FCOS[CO2]_a/GPP[COS]_a$

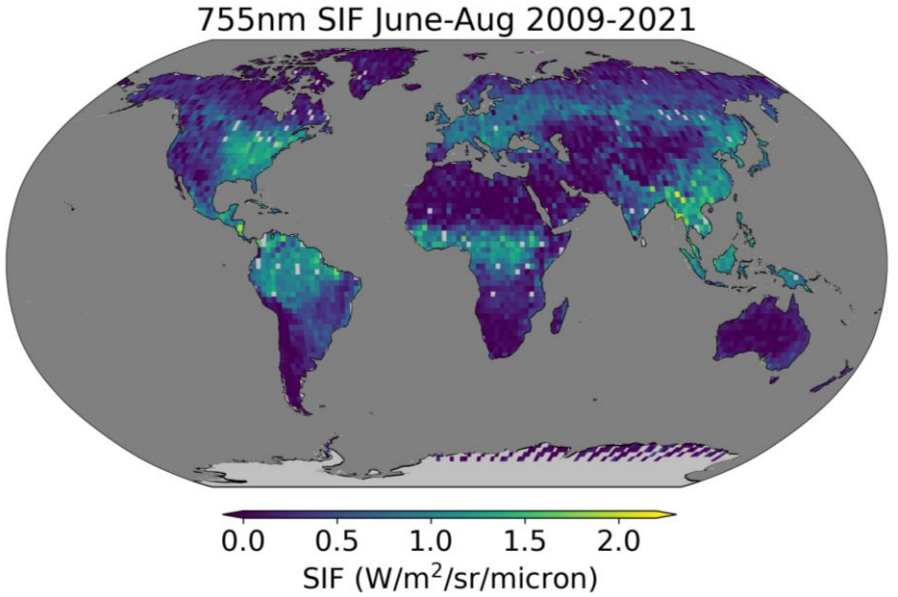
  LRU = leaf relative uptake

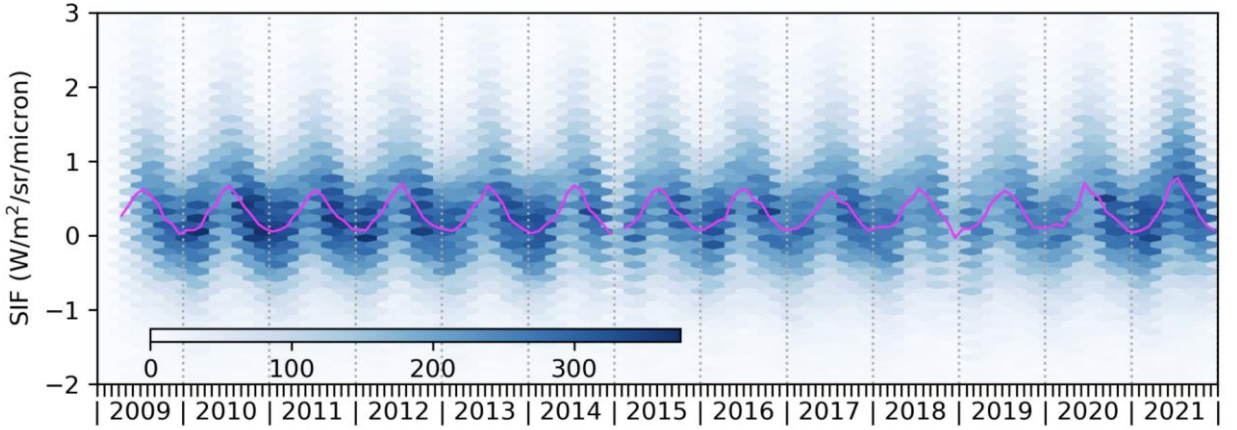
D. Moore, J. Harrison (U. Leics); C. Wilson, M. Chipperfield (U. Leeds)

Solar Induced Fluorescence (SIF)

- Related to GPP – shows strong water stress signal on large scales
- NCEO produces our own long term SIF data from 2009 from GOSAT

A. Webb, H. Boesch, R. Parker (U. Leics)

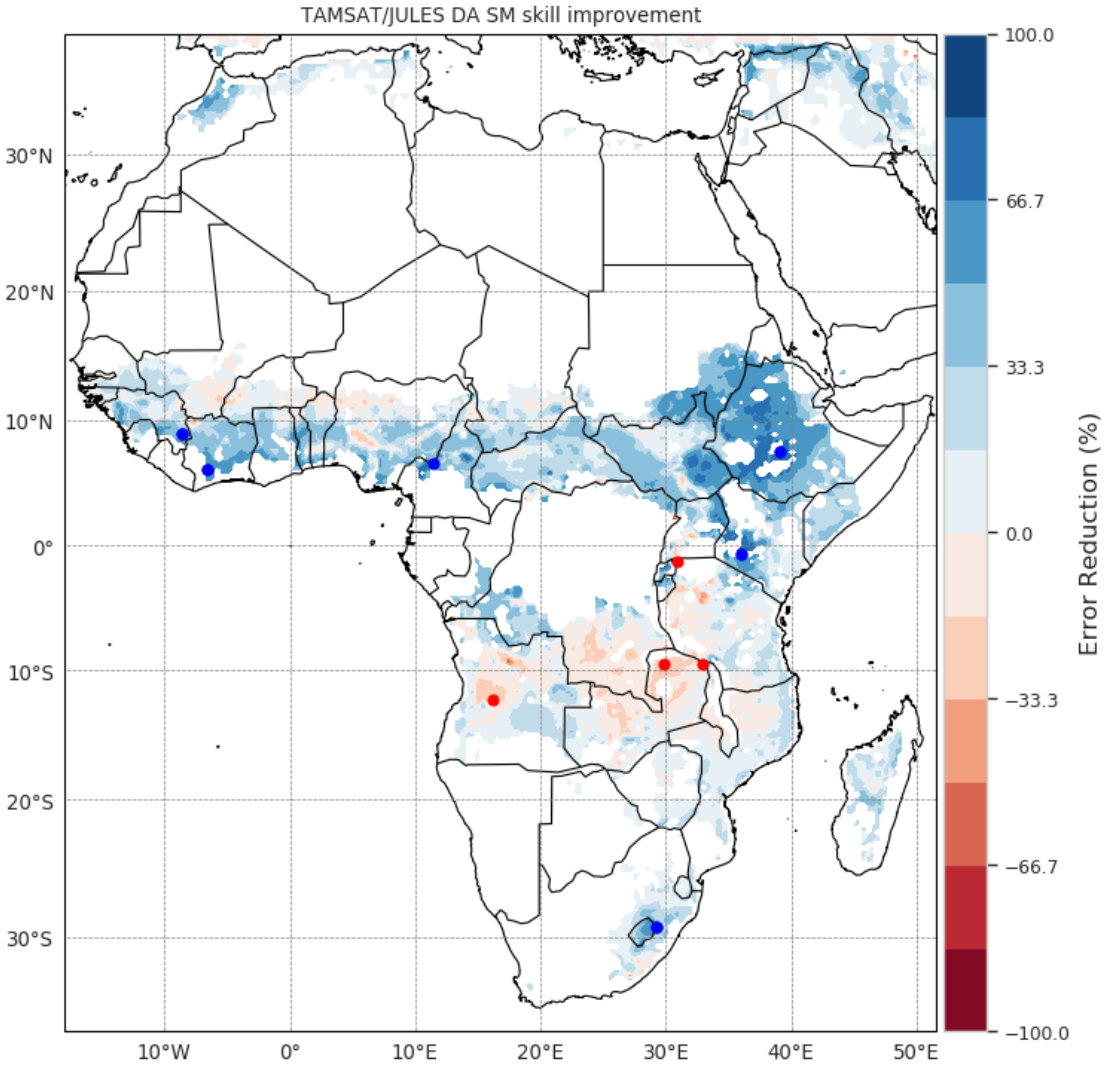




Time series of SIF data over North America Temperate TRANSCOM region – colourbar indicates number of soundings

Land model Data Assimilation with JULES

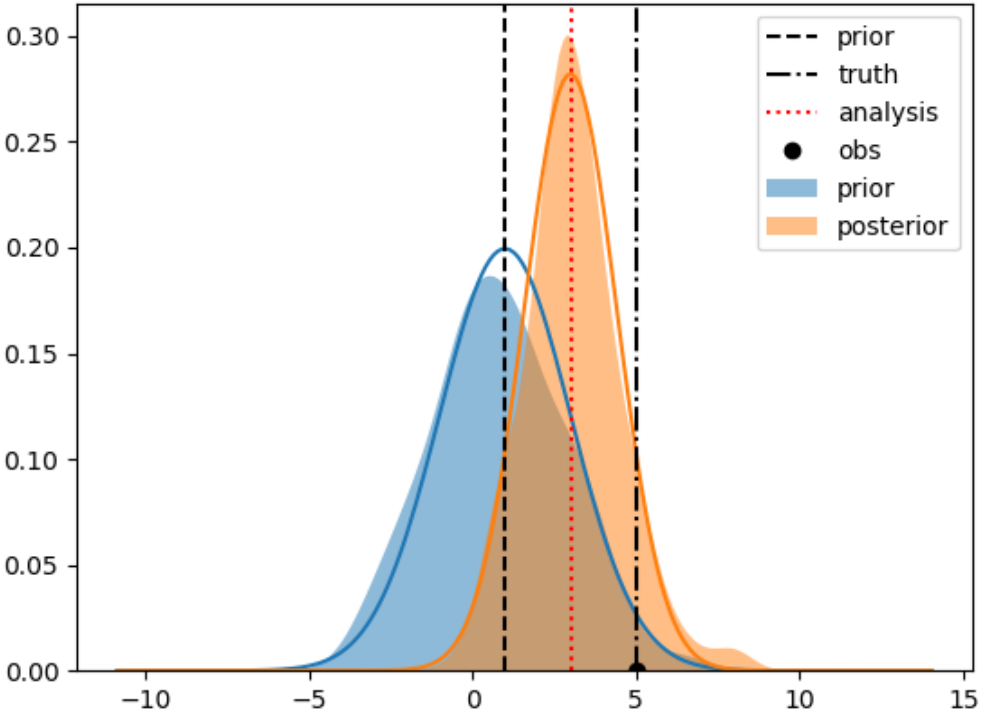
- Assimilate EO & site data to
  - At NEON sites
    - inc. flux data and aircraft EO
  - Across Tropical Africa
- Build new diagnostics for SIF & COS
- DA methodology for process selection
  - Stomatal conductance
  - Soil water stress



N. Douglas, T. Quaife (U. Read)

Generic Data Assimilation tool

- Will deliver a model agnostic DA tool
  - Based on our existing JULES DA system
- Uses a hybrid ensemble-VAR approach (4DEnVar)
- Minimal footprint on the model code
- User needs to generate ensemble



Collaboration with the international community

- We're actively seeking to set up new collaborations
  - Groups wanting to use our data/models/techniques
  - From groups who have data we could use
  - Get in touch if you're interested
- We will be **running a 2-day workshop at the end of March 2023**
  - In Leicester, UK at NCEO HQ
  - Funding to support international attendees

Knowledge Gaps and Priorities

- **Carbon-water links in LSMs/ESMs are poorly represented**
  - Soil moisture stress
  - Stomatal conductance in extreme conditions
- **Lack good prognostic models of factors controlling SIF**
  - e.g. NPQ
- **Need better retrievals of COS atmospheric concentration**
- **Quantifying uncertainty in observations remains challenging**
  - Especially *co*variances

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