This Workshop

Background

The ESA Support to Science Element (**STSE**) supports "**Earth Science Flagship Projects**". e.g. GEWEX (WACMOS Land Flux), SPARC (SPIN), CLiC (North Hydrology), SOLAS (OceanFlux GHG, Seaspray, Upwelling), iLEAPS, ...

New opportunity for **Ocean Heat Flux** with CLIVAR

"Great opportunity for collaboration around the world to improve globally important data sets that are iconic for climate sciences", Martin Visbeck

Participants

- 20+ across disciplines, world experts

Objectives

- Review existing activities, gaps & opportunities.
- Identify the scientific requirements for a CLIVAR/ESA activity this year.

Outcomes

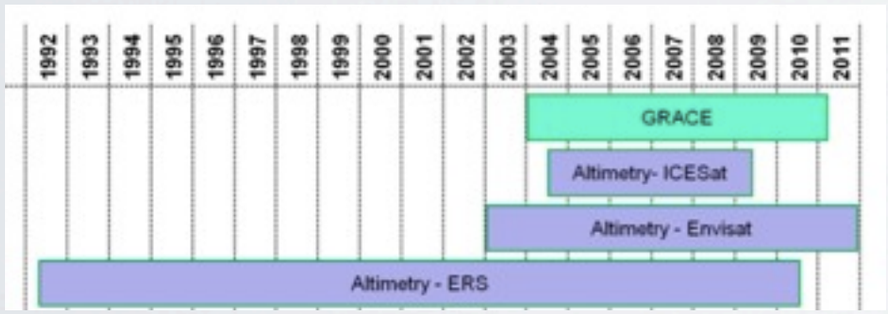
- **EO requirement document** for ESA
- Roadmap document input for CLIVAR Community White Paper

Ice Sheet Mass Balance Inter-comparison

Reconciling errors from independent measurements. e.g. altimetry, gravimetry, INSAR

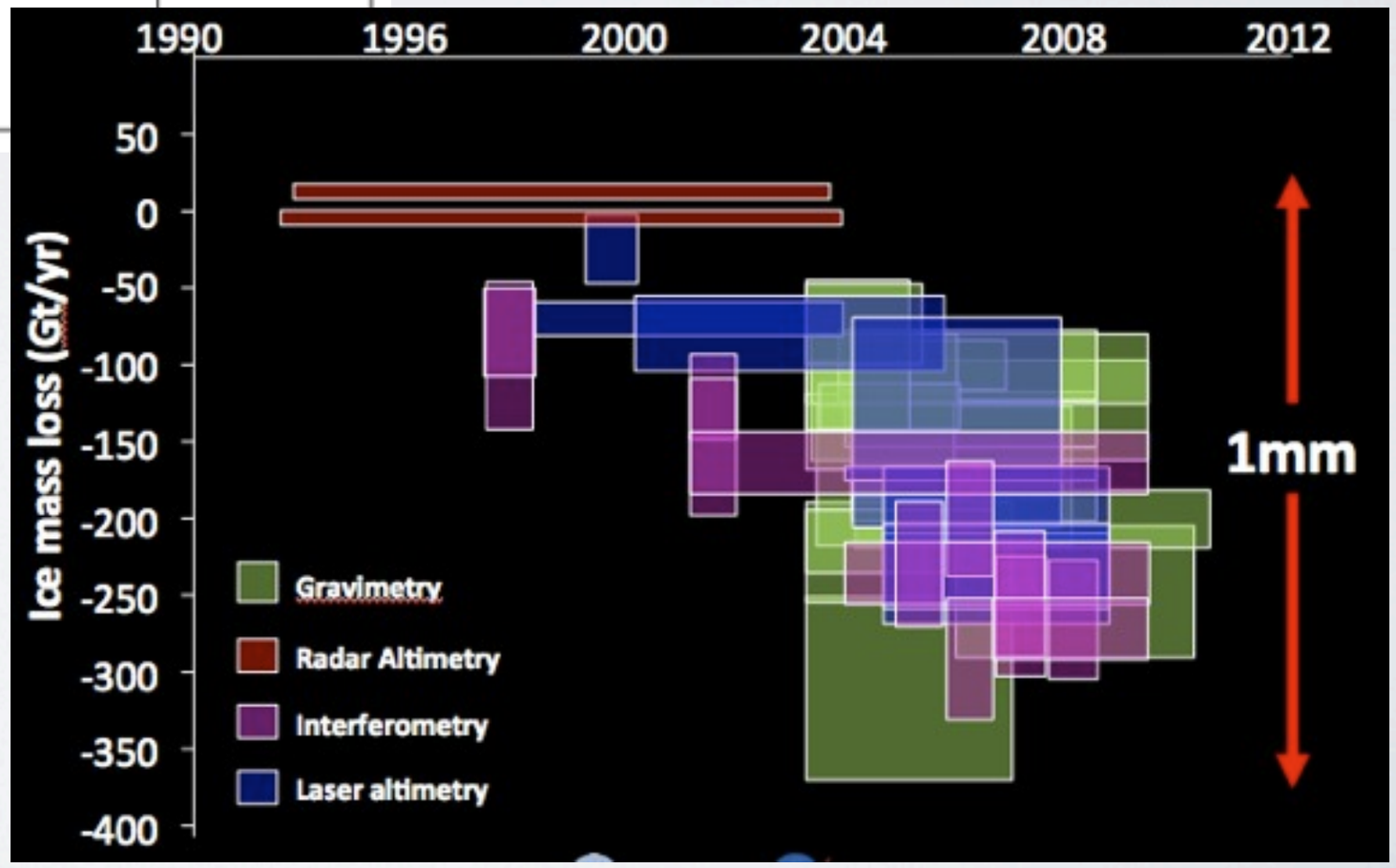
Altimetry	Gravimetry	Mass Budget	Surface Mass Balance (SMB)	Post Glacial Rebound (PGR)	Independent
Rene Forsberg	Srinivas Bettadpur	Eric Rignot	Michiel van den Broeke	Erik Ivins	Tony Payne
Hamish Pritchard	Scott Luthcke	Andrew Shepherd	David Bromwich	Glenn Milne	Ted Scambos
Ben Smith	Ernst Schrama	Adrian Luckman		Pippa Whitehouse	David Vaughan
Duncan Wingham	Isabella Velicogna	Ian Joughin		Dick Peltier	Stan Jacobs
Jay Zwally	John Wahr	Helmut Rott			
	Martin Horwarth				

45 investigators, 26 partners
NASA / ESA



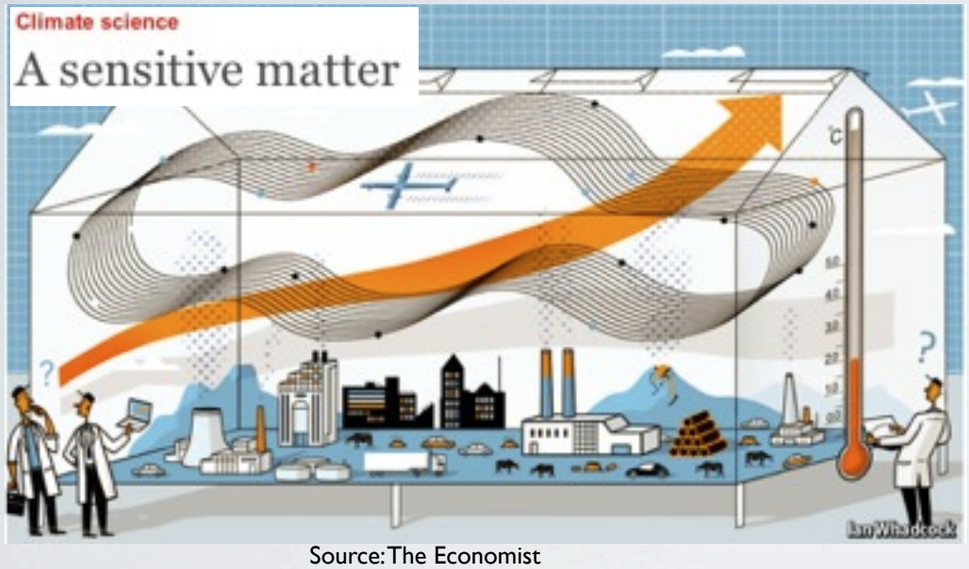
epoch I: overlap2003-2008
epoch II: IPCC 2005-2010

Ice sheets have contributed to 11+mm global sea level since 1992 (1/5 total). 2/3 from Greenland. Recent acceleration of melting.

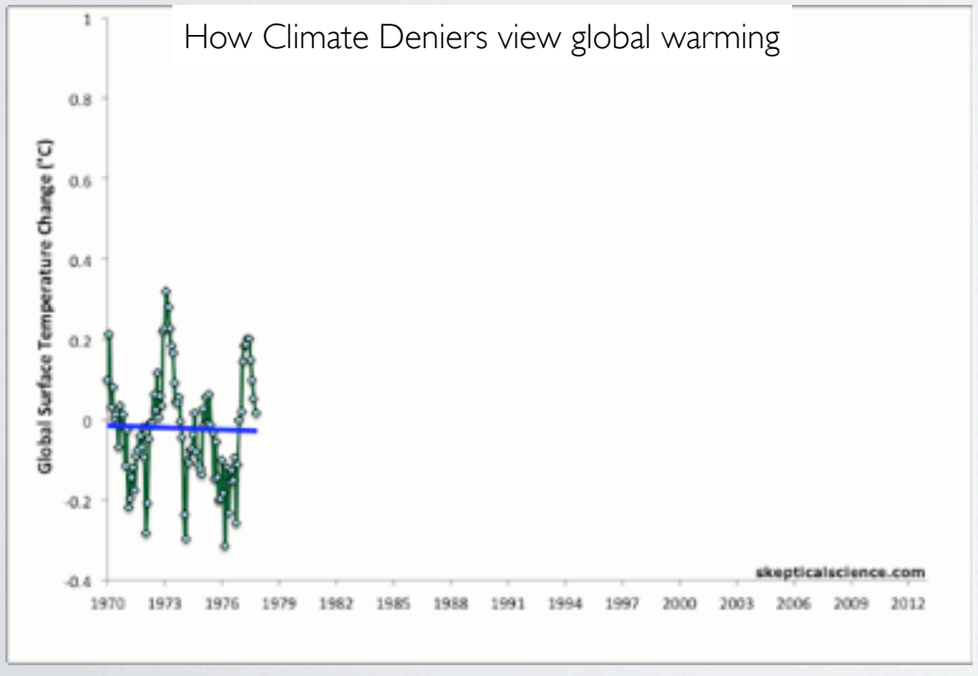


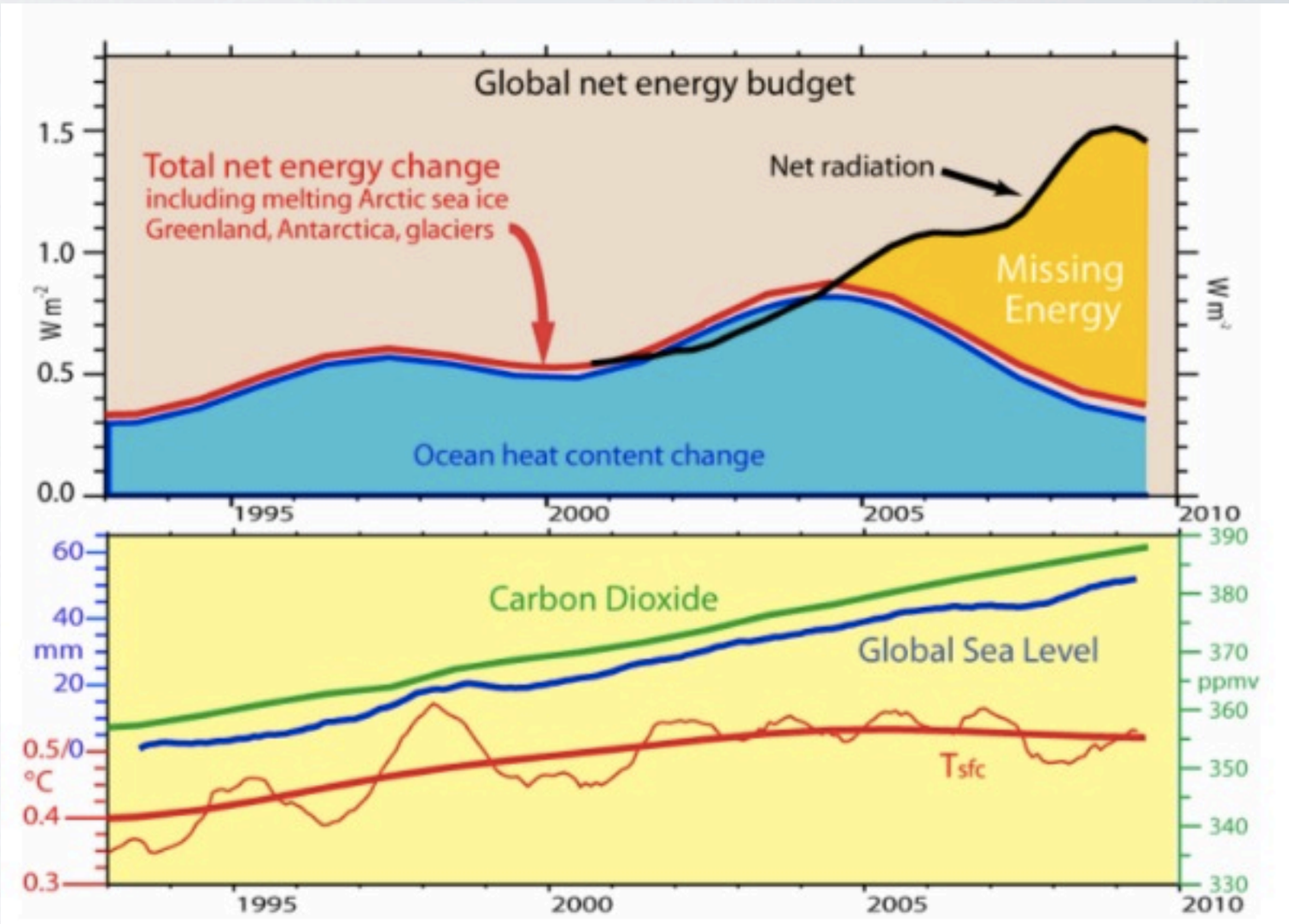
Focus on Heat Budget

- Challenge of Closing the Planetary Heat budget,
- Key role of the Ocean, biggest heat reservoir.



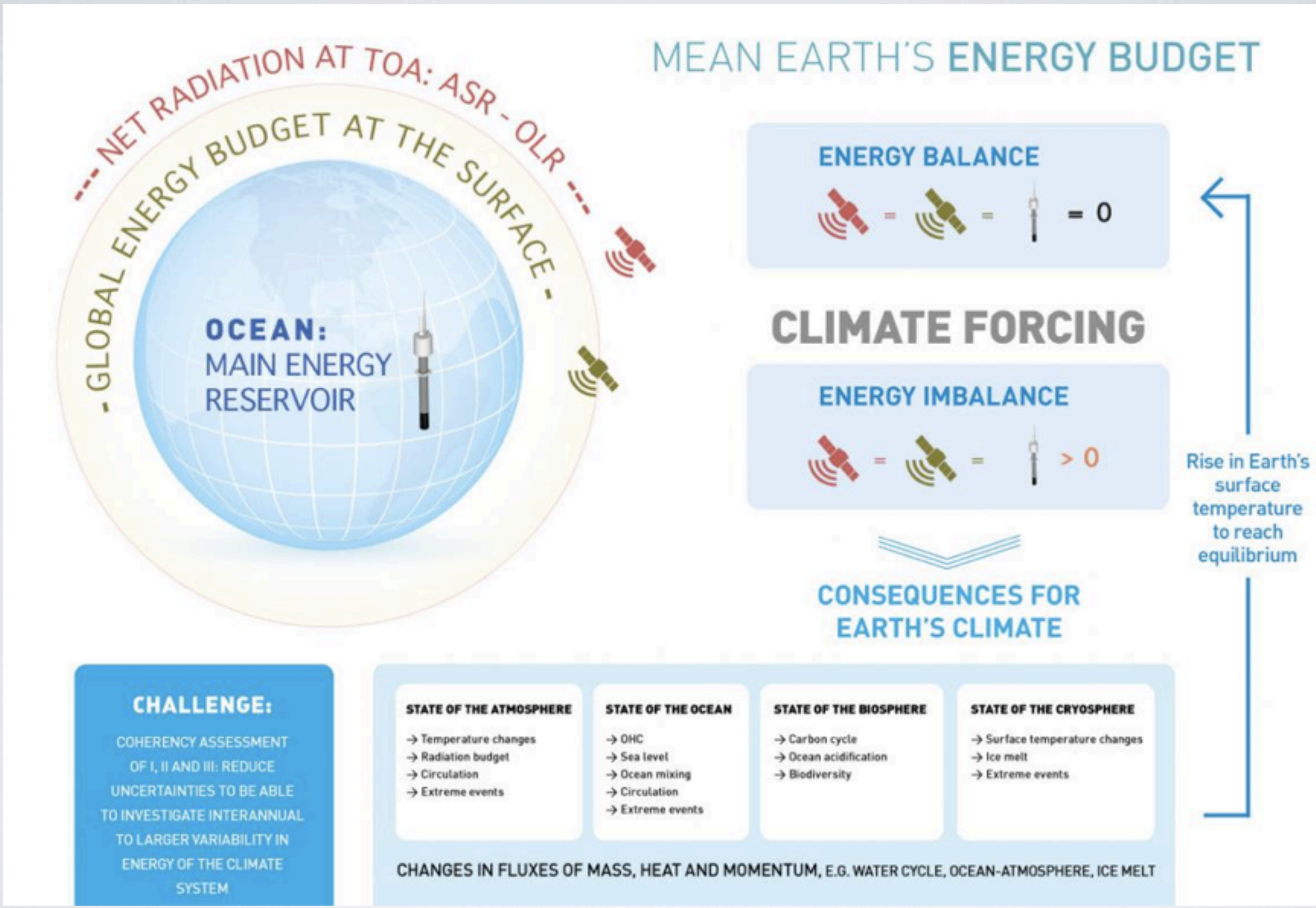
Source: The Economist





Source: The Economist, sckepticalscience.org, Trenbert et al.,

New CLIVAR Research Opportunity



Source: Karina von Schuckmann, clivar.rog

Specific focus on Air-Sea Heat Fluxes

Air-Sea fluxes are a key WCRP **cross-cut** focus of WCRP, across **programmes** (GEWEX, CLIVAR, SOLAS, iLEAPS, CLiC), and **data** (EO, in-situ, models),

- WCRP Working Group & GEWEX LandFlux - SeaFlux
- Action plan on Surface Fluxes (2012), WOAP meeting (Frascati, 2012)
- GSOP workshop in WHOI (Nov 2012), obs + synthesis for joint evaluation

Workshop Report

Towards achieving global closure of ocean heat and freshwater budgets: Recommendations for advancing research in air-sea fluxes through collaborative activities

Report of the CLIVAR/GSOP/WHOI Workshop on Ocean Syntheses and Surface Flux Evaluation

Woods Hole, Massachusetts, 27-30 November 2012

Lisan Yu, Keith Haines, Mark Bourassa, Meghan Cronin, Sergey Gulev, Simon Josey, Seiji Kato, Arun Kumar, Tony Lee, Dean Roemmich

May 2013

WCRP Informal/Series Report No. 13/2013
ICPO Informal Report 189/13

Recommendations

- **Regional Heat/Salt budget analysis**
- Direct point wise comparison with OceanSITE
- Metrics for flux evaluation
- Requirements on Products
- Requirements on Infrastructure
- **Perspective of CAGE experiments**

(Bretherton, 1986)

Source: clivar.org

Wealth of Data Sets

$Q_{net} = Q_{LH}$ (Latent) + Q_{SH} (Sensible) + Q_{SW} (Short Wave) + Q_{LW} (Long Wave)
$Q_{net} = F(p, x)$

x= dT[air-sea temp diff], q_a[humidity], W[wind speed], SST,
roughness / slope, Water Vapour, Clouds, Aerosols ...
p= C_p , C_e , C_h, +other parameterisations

Wealth of flux data sets

- Atm Re-analysis (e.g. NCEP / CFSR, NASA / MERRA, ERA-CLIM, JRA)
- Ocean Synthesis (e.g. ECCO, Mercator)
- Empirical Bulk Formulas
  - in-situ (e.g. ICOADS NOCS)
  - EO (e.g. HOAPS [de], GSSTF [us], J-OFURO [jp], SeaFlux [us],...)
  - Hybrid (e.g. CORE.2, DFS4, OAFlux, ...)

but **not** necessarily **consistent** with heat budget constraints!!

Use of **EO**, mainly non European, need for a "Flux Train"
e.g. Ta/q (SSM/I, AMSR-E), SST (reynolds, AVHRR..), W (SSMI, QuickScat,..),

Challenges

Generating

- Need for new algo? parameterisations?
  e.g. probabilistic approach
- Need for new data?
  e.g. air-sea Temp

Validating

- Ground truth ?
- Indirect measurement (issue of incest),
- In-situ (point-based),
- Poor Sampling:
  - Sparse (few buoys),
  - Uneven (better in the tropics!)
- Use of inter-comparison of products!

Need to ensure **consistency**
with Heat Budget Constraints

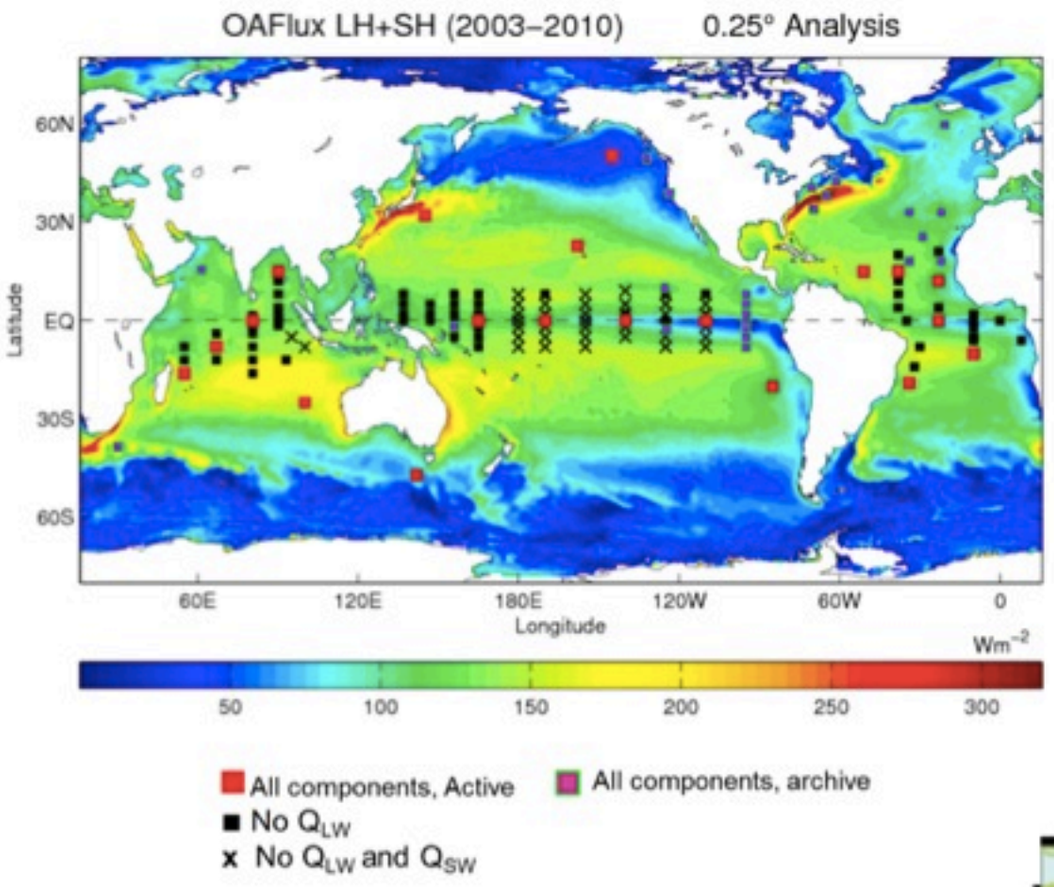
Quantifying Uncertainty

- Difference of Large Numbers
- Sampling issues,
- Representativity error,
- Empirical derivation.

Evaluating

- Need for new methodology?
- Reference data?
- Metric? Suitability? Usefulness?

Opportunities (from in-situ data)

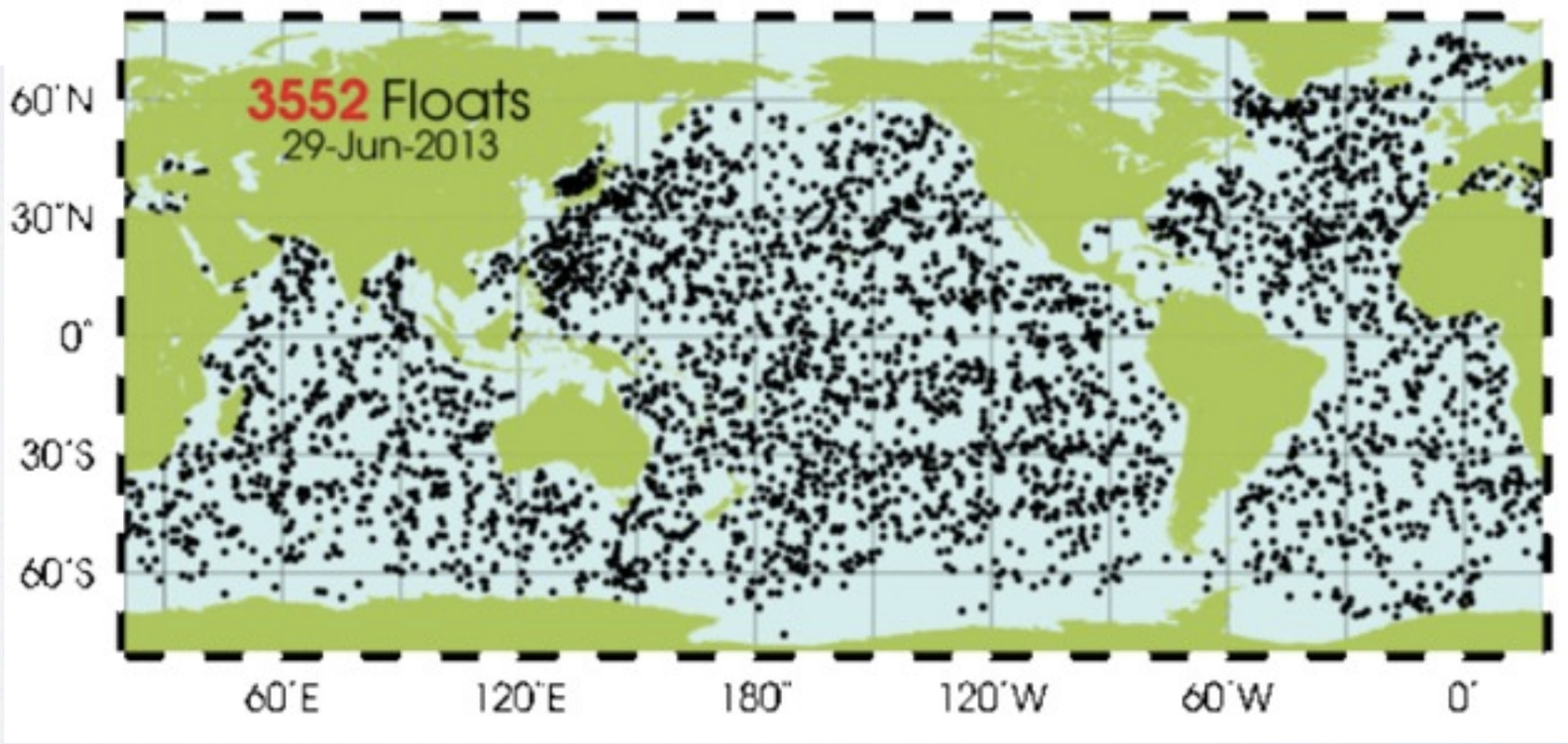


BUOYS / SITES

- Idea of Super Sites, Reference Sites
- 85% buoys in tropical regions
- about 20 active full-flux buoys
  + OceanSITES

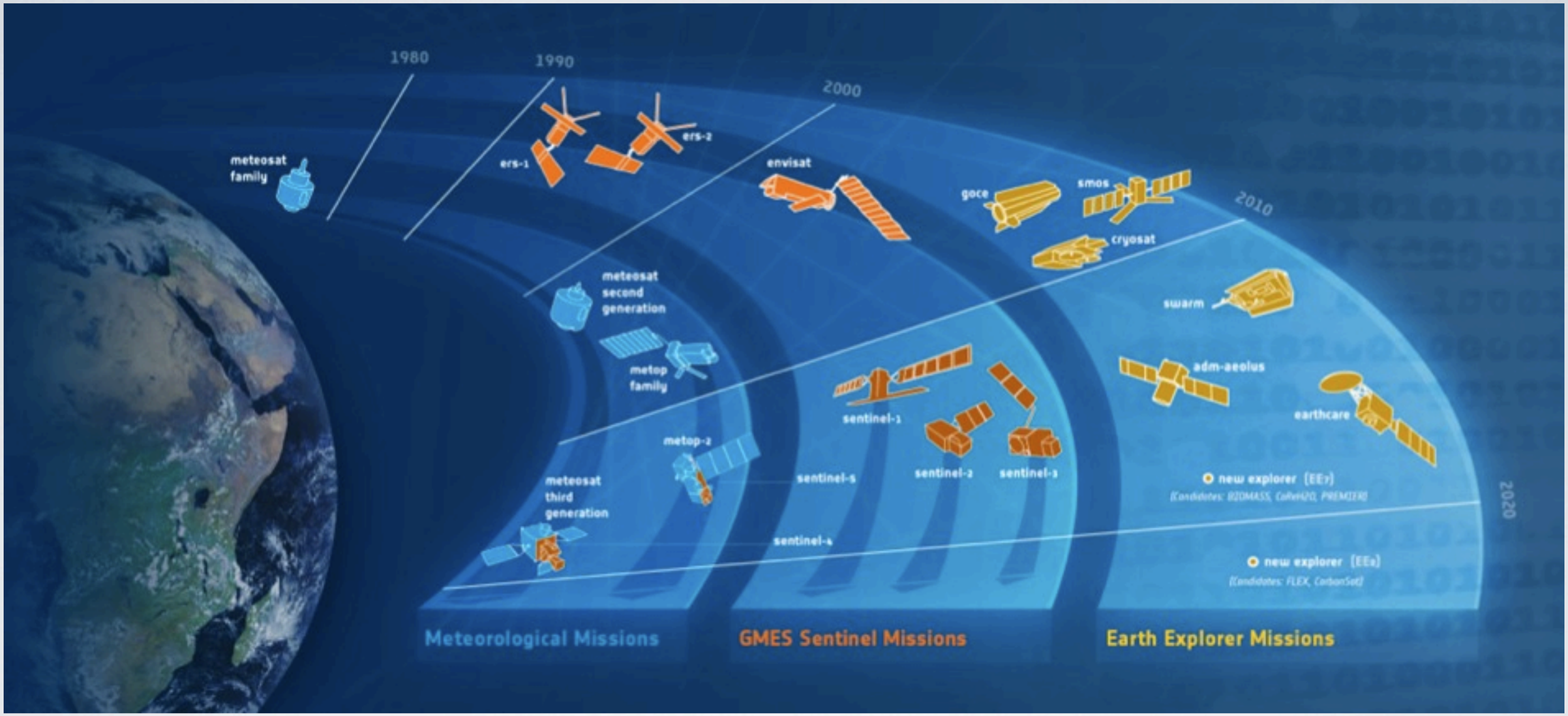
FLOATS

- 3000+ Argo floats for T/S profiles
- Sampling of upper ocean 2000m
- 7+yrs complete data
- **Focus on Argo period** 2004+



Source: GSOP report, Argo web site

Opportunities (from EO data)



Missions

- 20yrs archive ERS, Envisat + Explorers (SMOS, Cryosat, GOCE)
- 20yrs of data to come, e.g. Sentinels, Met missions

Products

- ESA Climate Change Initiative CCI (e.g. SST, OC, Aerosol, Cloud)
- GLOB products (e.g. current, wave) + STSE products

Potential ESA/CLIVAR collaboration

STSE study [400K, 2yrs]

- Be important for CLIVAR, complementary to other activities e.g. SeaFlux
- Exploit EO data, in particular from ESA missions and programmes,
  - ESA missions: Envisat AATSR, Cryosat Altimetry, SMOS L-band?
  - ESA projects / products: CCI SST, GLOBWAVE
- Produce Concrete Science Results
- Be realistic, Focus on topic / region

Big Opportunity here to shape this activity!

Possible STSE Ocean Heat Flux?

The overarching objective of **Ocean Heat Flux** is to **Develop a *collaborative* "Ocean air-sea Flux Laboratory Platform" to *reconcile* EO-based air-sea fluxes with heat budget constraints derived from EO and sub-surface data**.
In particular, to achieve this objective the project will aim to:

- *Gather* input data sets to derive air-sea fluxes from EO (e.g. W, SST, OC, Altimetry, Globwave, TOA..), ancillary data (Met data, Reanalysis, with associated meta-data), and ground truth (e.g. direct/indirect flux measurements), on one collaborative portal to enable easy inter-comparison of products.

- *Generate an ensemble of fluxes* based on existing data sets (e.g. HOAPS) and latest developments in algorithms and data, maximising the use of ESA data and products such as CCI. e.g. the ensemble would explore space of parameters and hypothesis, (e.g. wave/no wave, averaging SST), ..

- *Develop* a strategy to perform assessment of fluxes, at regional spatio-temporal scale, exploiting heat budget constraints.

- *Identify* "Reference" Regions (e.g. natural/pre-defined CAGES, Bubbles, Medsea) and time windows suitable to perform evaluation of flux (e.g. good signal to noise).

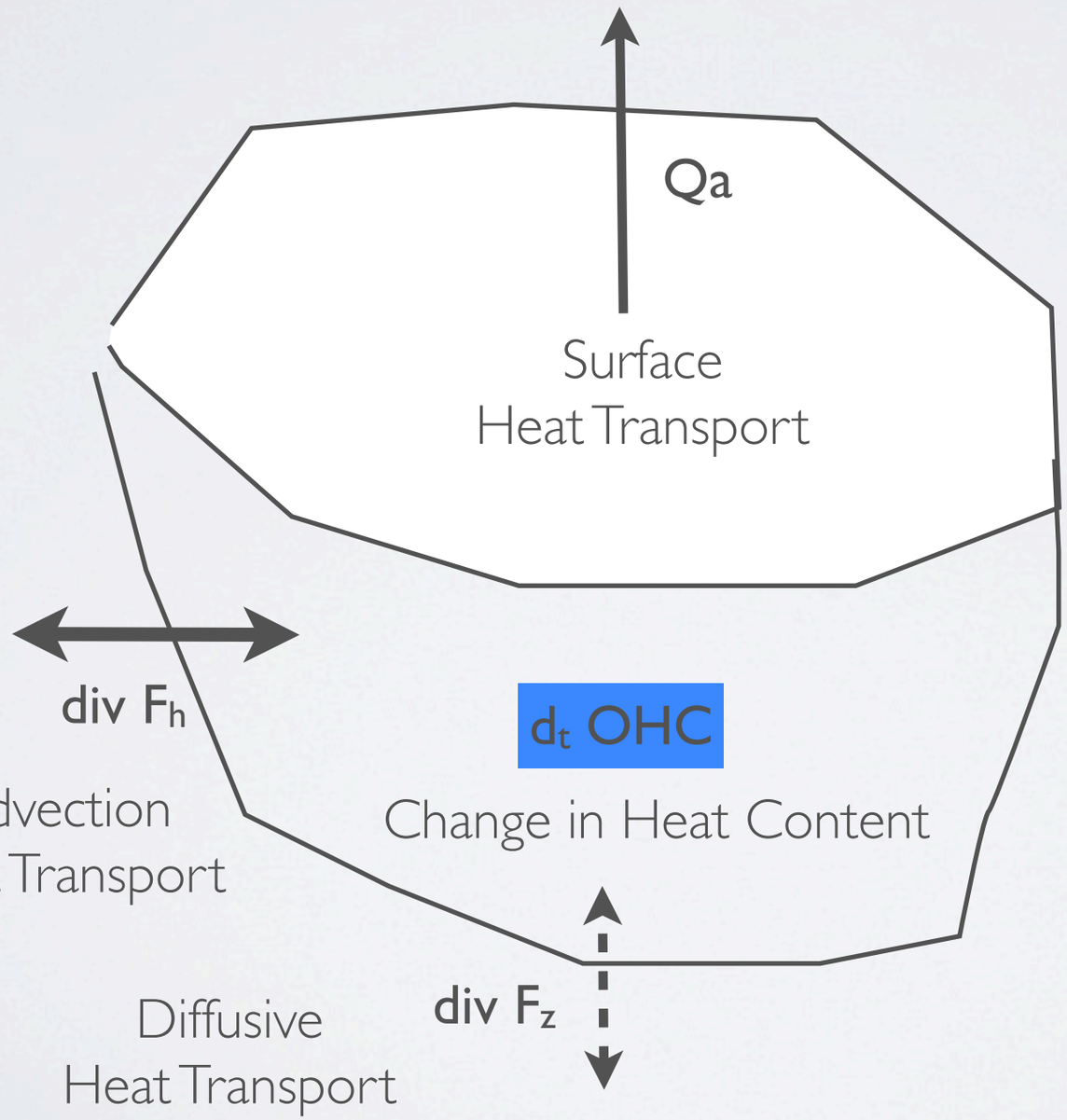
- *Quantify Quality* of fluxes, and parameterisations, through comparison with *in-situ* and regional constraints.

- *Provide* ESA with recommendations of future work and satellite missions useful to address the CLIVAR research opportunity on planetary energy budget.

Exploiting Heat Budget Constraints?

Bubble Analysis, identify adequate reference "CAGE" regions:
e.g. Pacific Warm Pool, Med Sea, Tropical Band, ..
e.g. closed regions where div F known or small ...
e.g. Time window, depending on events e.g. ENSO, availability of data

Ocean Synthesis
to enable optimal sampling of suitable reference regions

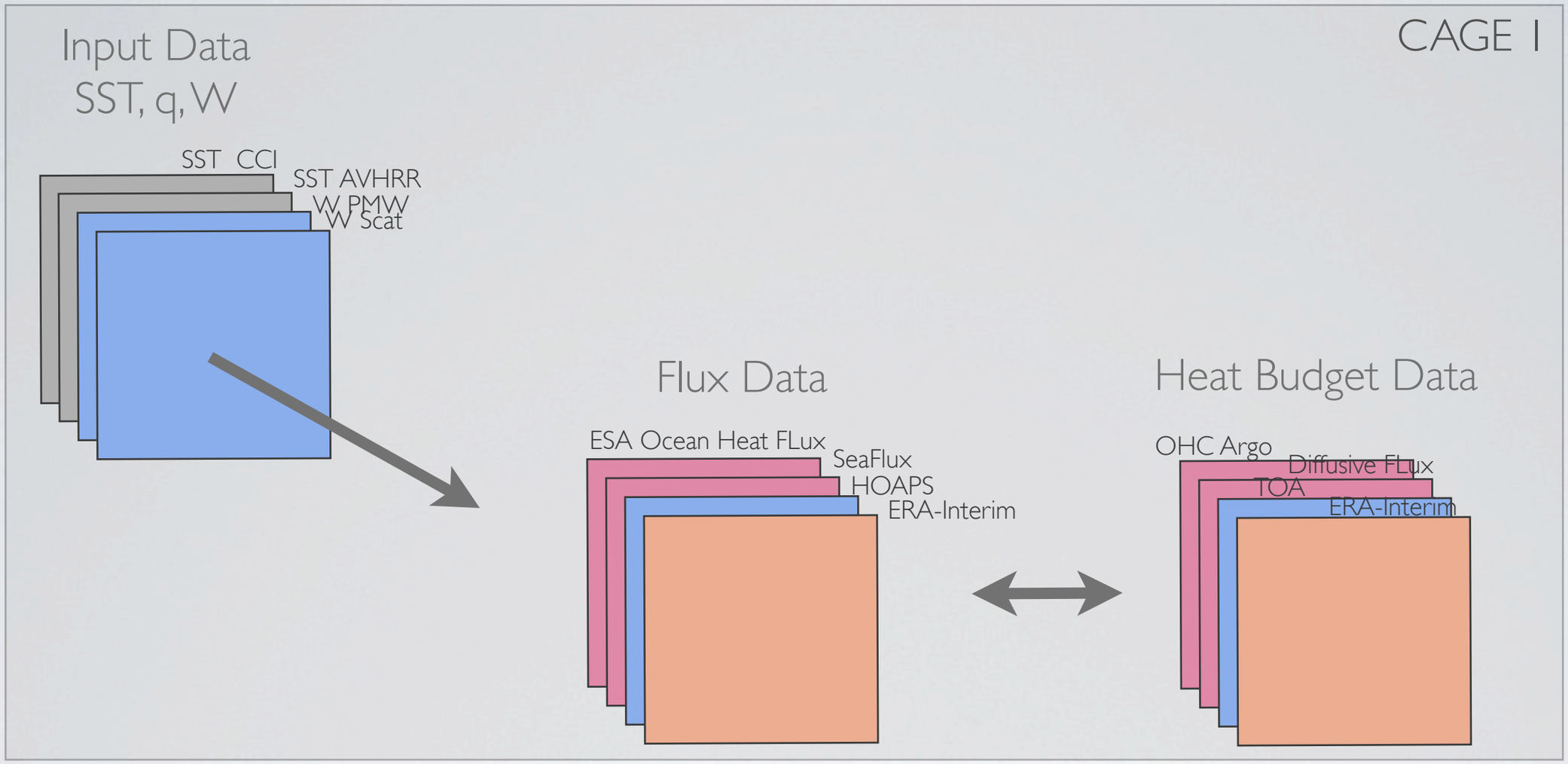


EO obs
Barotropic (RA)
SST (AATSR)
W (ERS)
Absorption (MERIS)

In-situ obs
OHC (Argo)
Q Fluxes (Buoys)

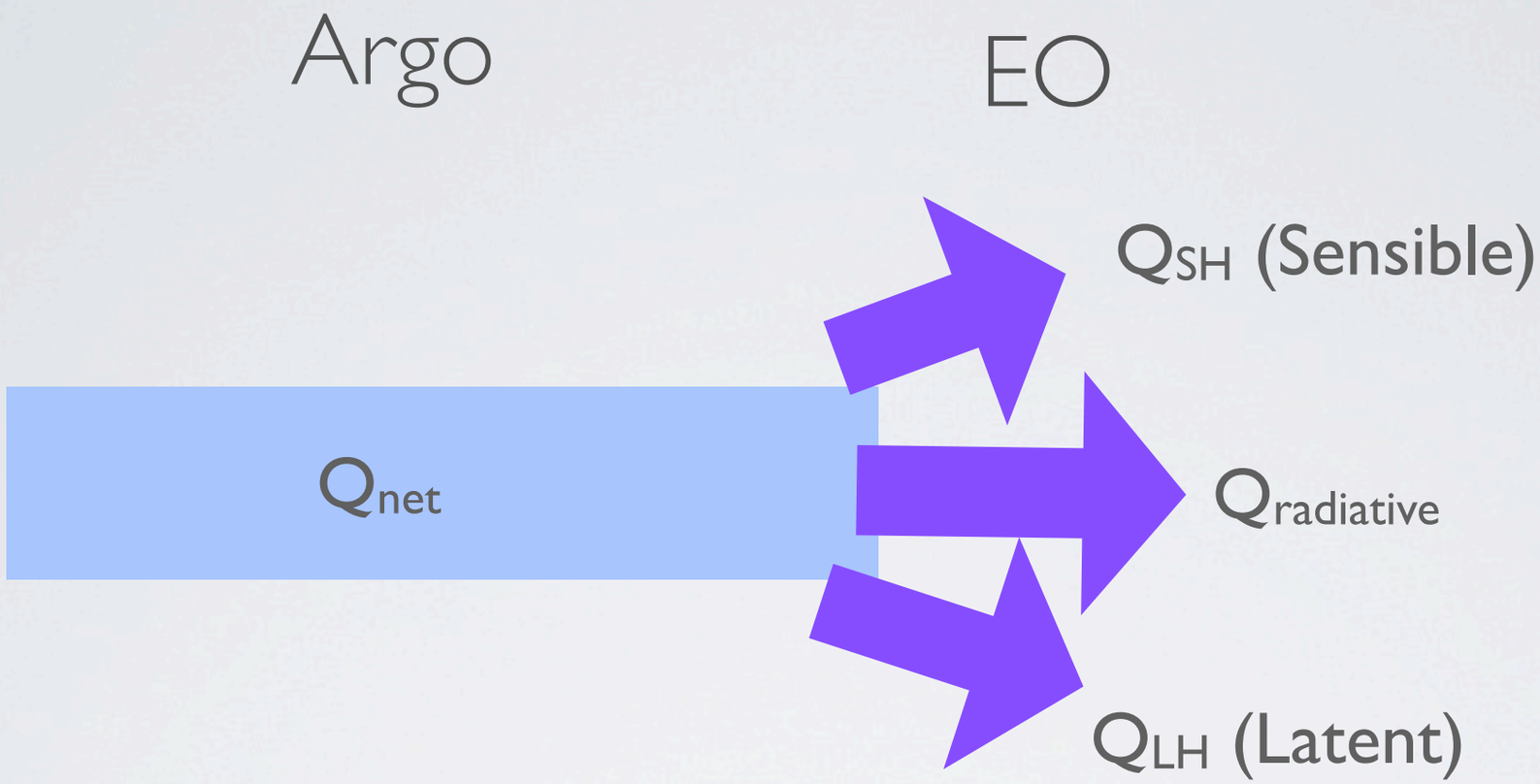
Air-Sea Flux Regional Cage Laboratory?

Test Bed Environment for Consistency Assessment



- Test - benchmark flux algorithms & parameterizations
- Assess Consistency / Quality .. Heat / Freshwater ?
- Quantify sensitivity, perform effective inter-comparisons
- Recalibrate parameters regionally
- Flexible to integrate other layers e.g. land fluxes

Need for EO-ARGO Flux-type Product?



New flux retrieval algorithm based on a variational approach to partition fluxes components on the CAGES regions