Indicators of the Climate System

D Carlson
Director, WCRP
Indicators of the entire system?
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- Heat / energy
- Carbon - CO$_2$ and CH$_4$
- Sea Level (heat & water)
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As budgets: inputs - outputs = net change
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As budgets: sources - sinks = net change
Budget: Local total = global mean rise + regional variability + local oceanic processes + vertical land motions
Budget: emissions + land use change = atmospheric concentration + ocean sink + land sink

Global Carbon Project: ESSD-2016-51
Carbon - CH₄

Global Carbon Project: ESSD-2016-25

Methane emissions (Tg.yr⁻¹)

Years

Budget: atmospheric concentration = natural sources + anthropogenic sources - chemical losses

Global Carbon Project: ESSD-2016-25
Earth’s energy imbalance

Schuckmann et al. 2016, Nature Climate
Earth's energy imbalance

Schuckmann et al. 2016, Nature Climate
Earth’s energy imbalance

Budget: incoming solar radiation = outgoing radiation + ocean heat

Schuckmann et al. 2016, Nature Climate
Energy versus surface temperature

24 CMIP5 models
pre-industrial controls
14,000 model years

Schuckmann et al. 2016, Nature Climate
Energy versus ocean heat content

24 CMIP5 models
pre-industrial controls
14,000 model years

Earth system energy change (W m\(^{-2}\))

Ocean heat storage change (W m\(^{-2}\))

Ocean heat content

Schuckmann et al. 2016, Nature Climate
Schuckmann et al. 2016, Nature Climate
ARGO floats

Argo Density
100% = 4 Floats

September 2015
Ocean heat content by ARGO

Roemmich et al. 2015
Nature Climate

Ocean Depth, m

0 400 800 1,200 1,600 2,000

0.200 0.150 0.100 0.050 0.020 0.010 0.005 0.000
-0.005 -0.010 -0.020 -0.050 -0.100 -0.150 -0.200

8 yrs

WCRP UNFCCC 2016.11.08
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- Assembled & calibrated by large teams of researchers
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- Annual (?) timescales
Climate challenges the human spirit