



Precipitation within the Earth system: A forward looking integrated perspective *

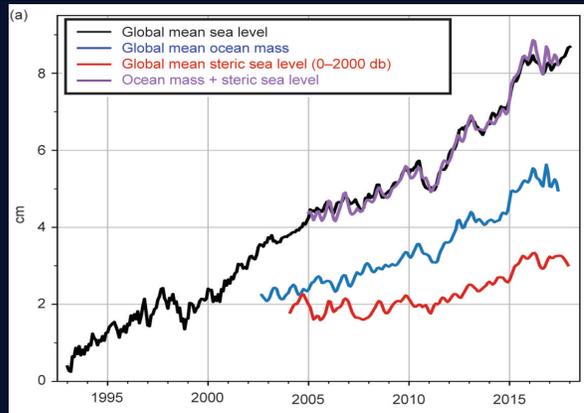
* Toward a process-oriented view

Graeme L Stephens

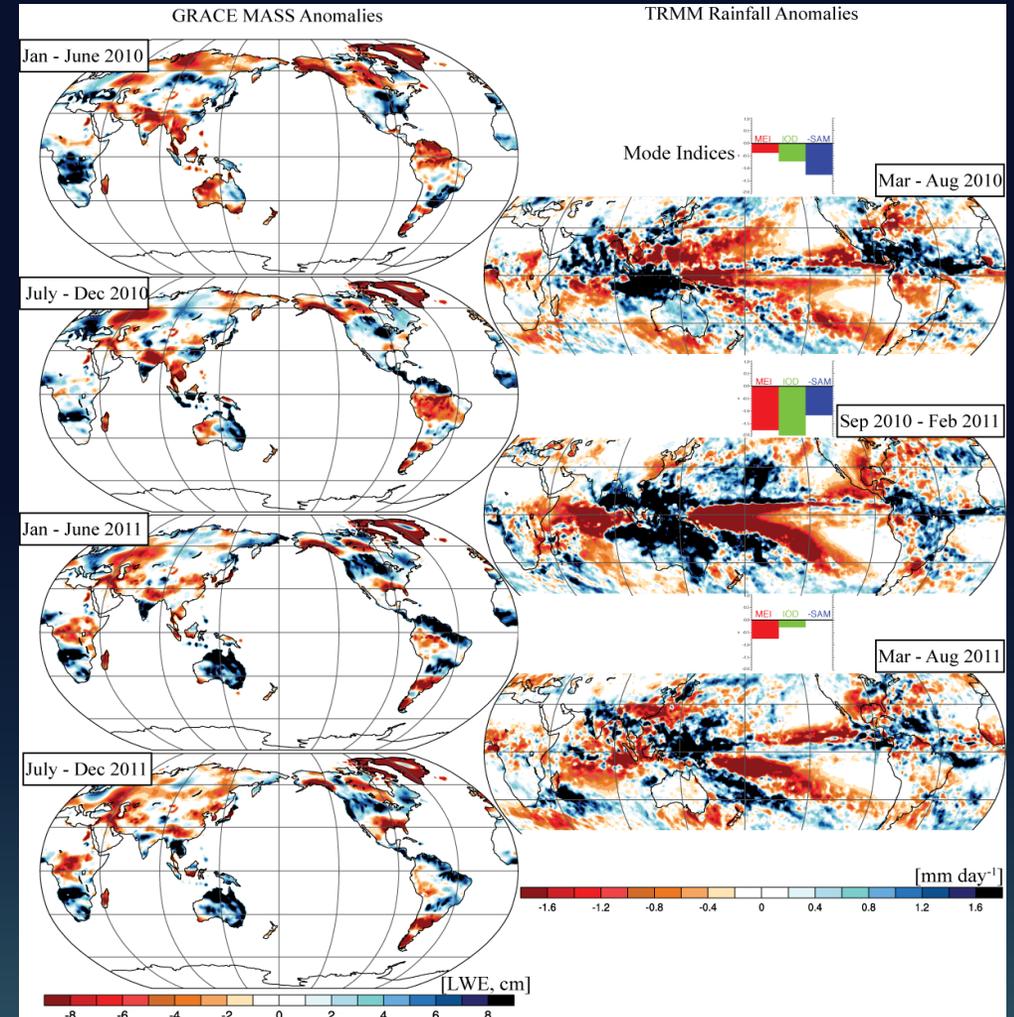
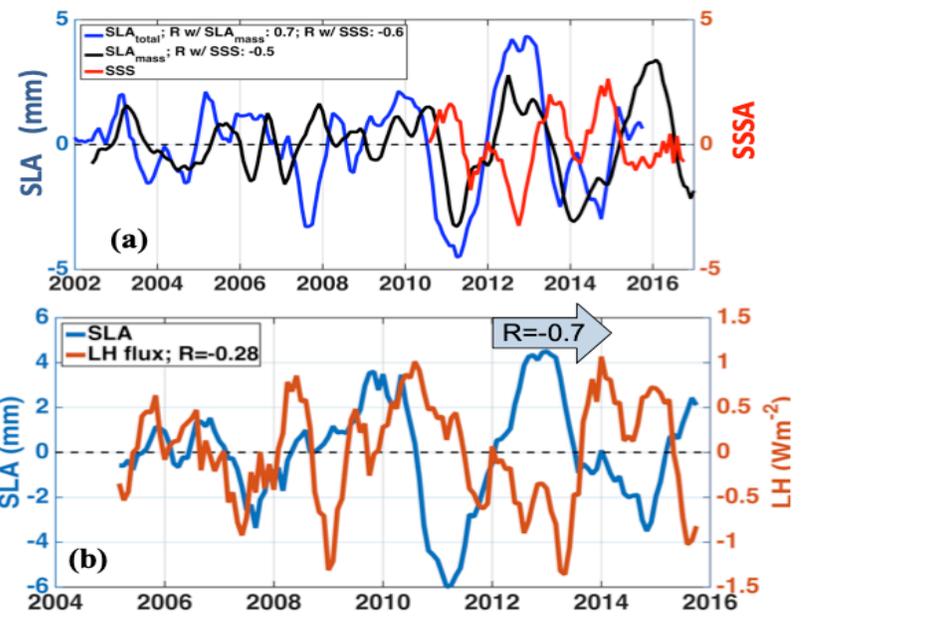
Jet Propulsion Laboratory, California Institute of
Technology

Professor Emeritus, Colorado State University

Precipitation: A key Earth system variable



Sea level interannual variabilities are large and shaped by fluctuations to Earth's hydrological cycle and the shifts in patterns of precipitation are central to the variability observed



Documenting Precipitation & quantifying processes that define it : a major Earth system challenge



Same monthly accumulation (75mm)

Accumulation (total water that falls over some period of time

~ mean precipitation

The **frequency** (how

The **duration** (how

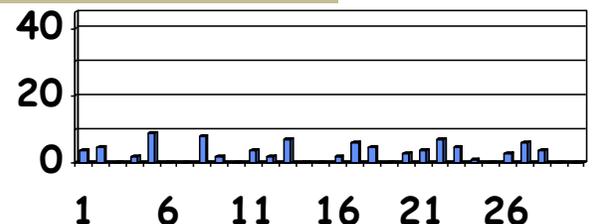
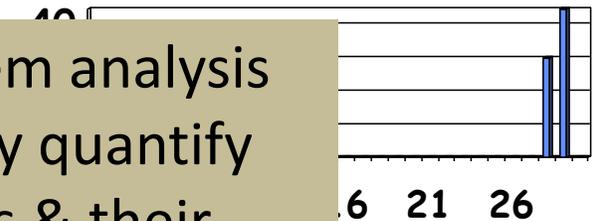
The **intensity** (the
CloudSat...)

The **sequence** (pre
moisture) (inferred from

The **phase**: snow or rain (CloudSat)

Develop and evaluate an integrated Earth system analysis with sufficient observational input to accurately quantify the components of the water and energy cycles & their interactions, and close the water balance from headwater catchments to continental scale river basins ... MI objective of the ESAS2017 Hydrology Panel

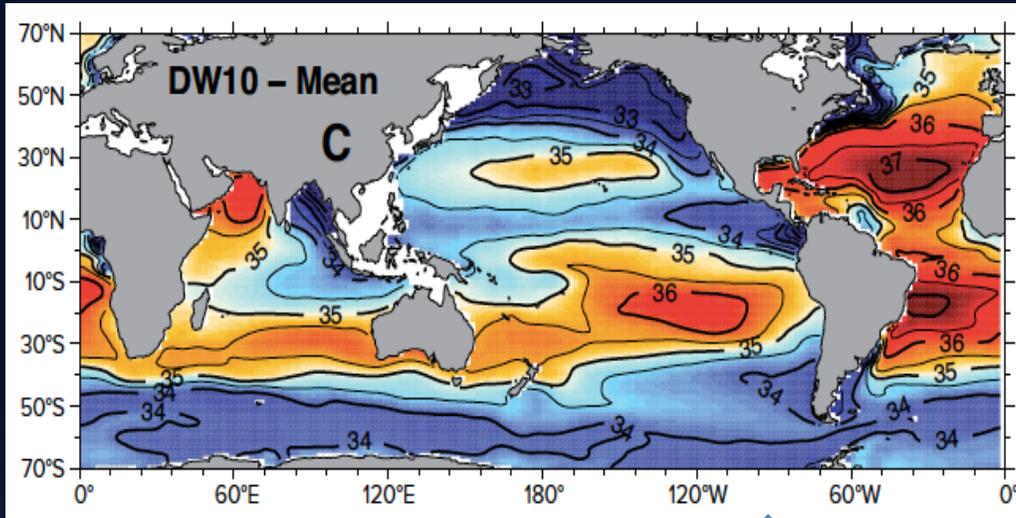
The intensity, sequence and phase all affect how much runs off versus how much soaks into the soils. The hydrological consequences are profound



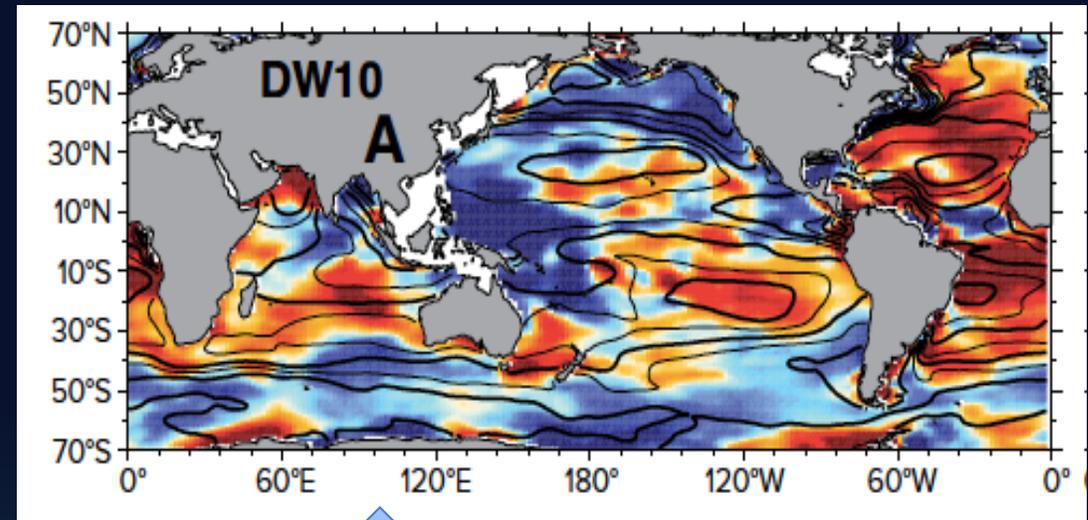
Frequency 6.7%
Intensity 37.5 mm

Frequency 67%
Intensity 3.75 mm

Global salinity: a measure of how precipitation patterns change over our oceans



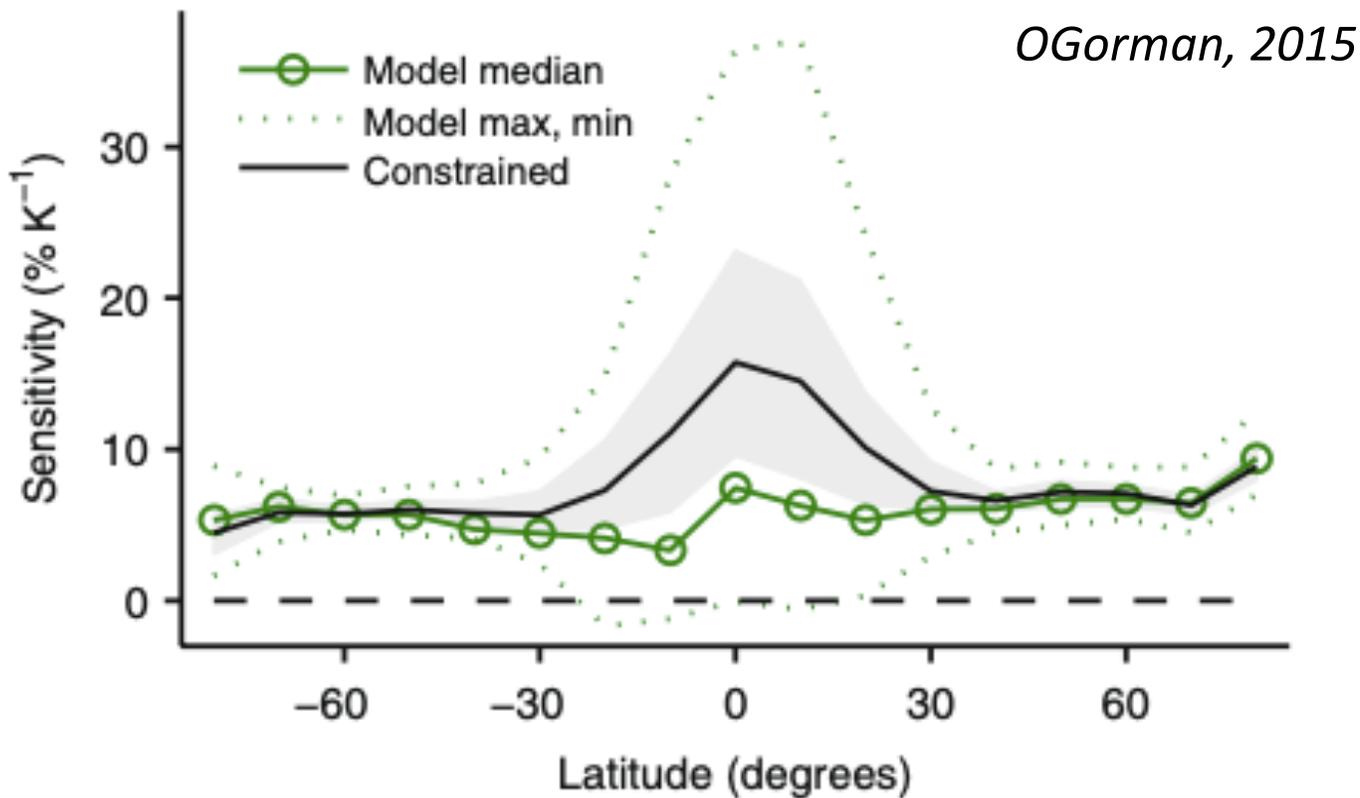
Salinity climatology



Patterns of change

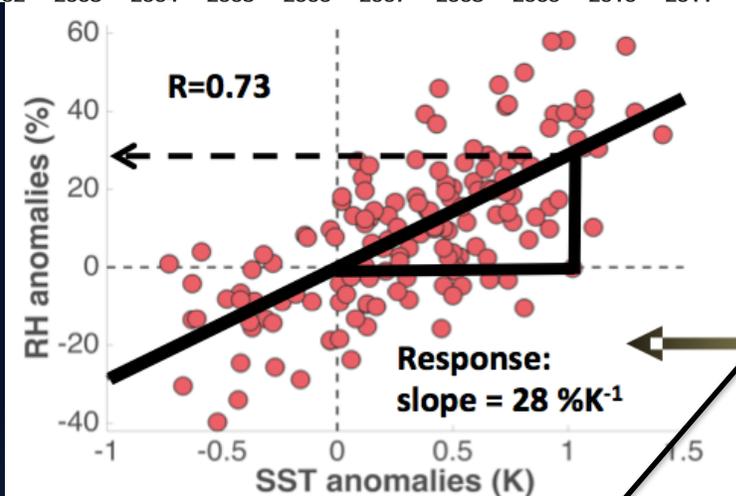
These patterns
look the same

It implies wet regions (fresher ocean water) , become wetter
and dry (more saline) regions drier OVER oceans

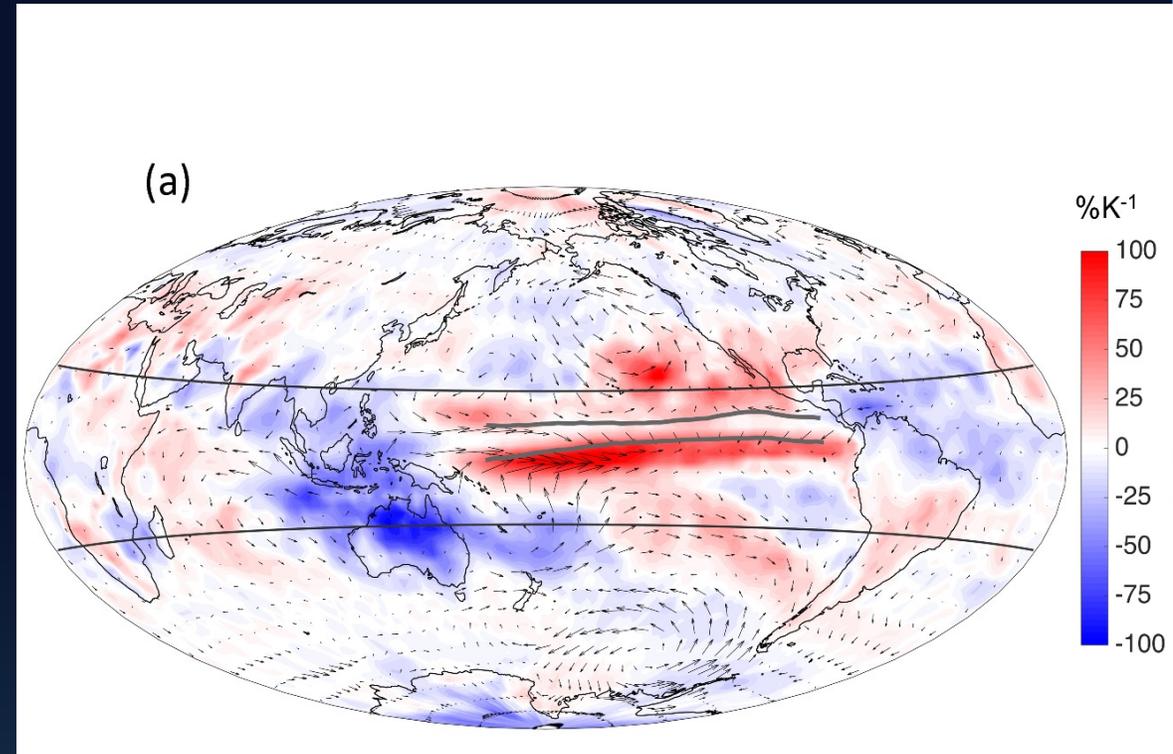


Are the changing tropical rains super Clausius-Clapyeron?

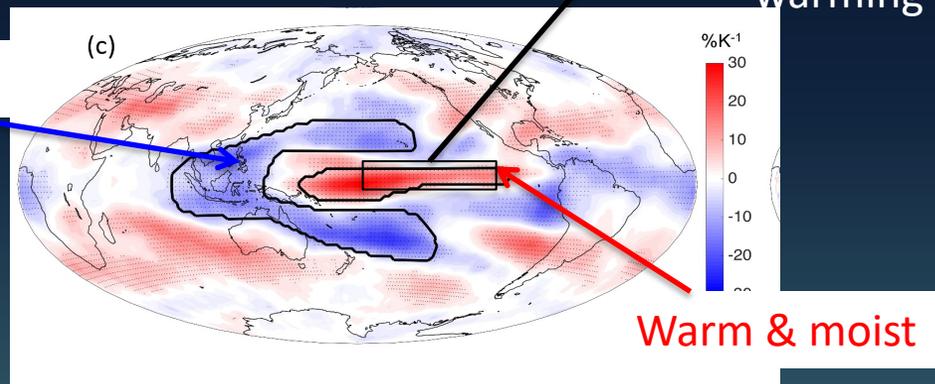
Convection – precipitation feedbacks within ENSO



The global UTH response to Nino3 warming



GPCP precipitation response (relative)
Surface wind response (MERRA)
Mean location of ITCZ

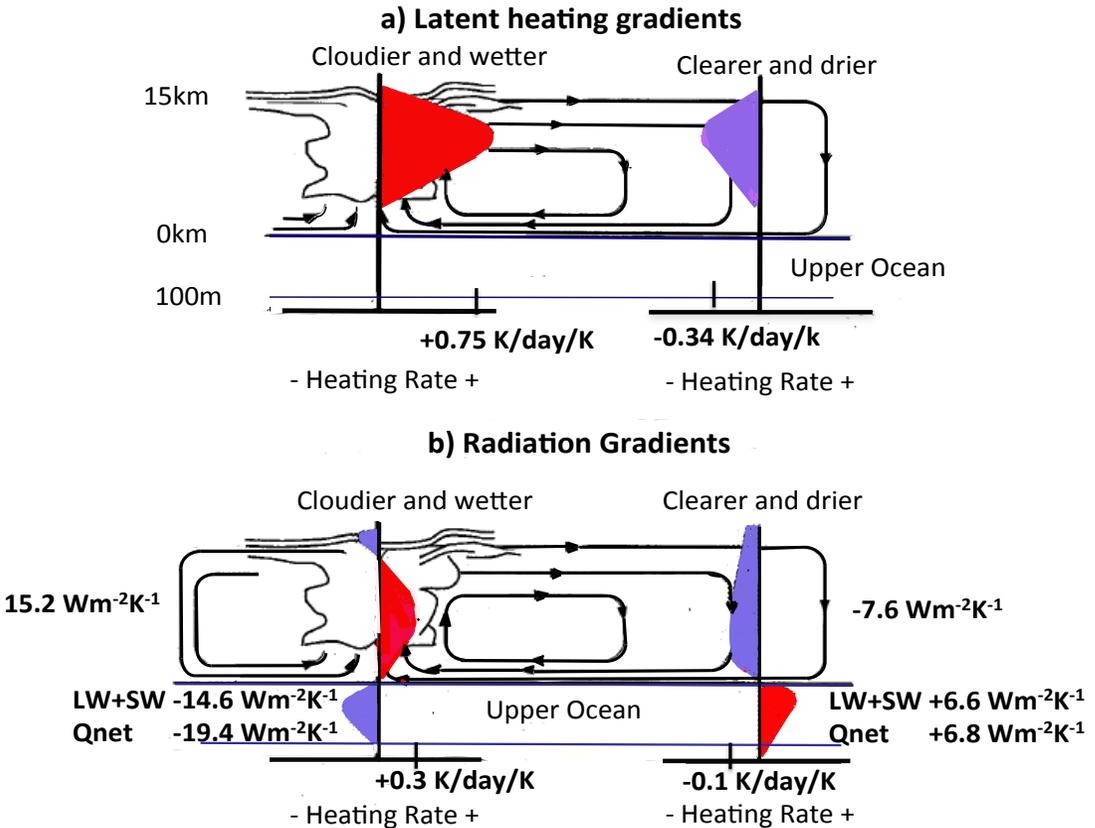


Cold & dry

Warm & moist

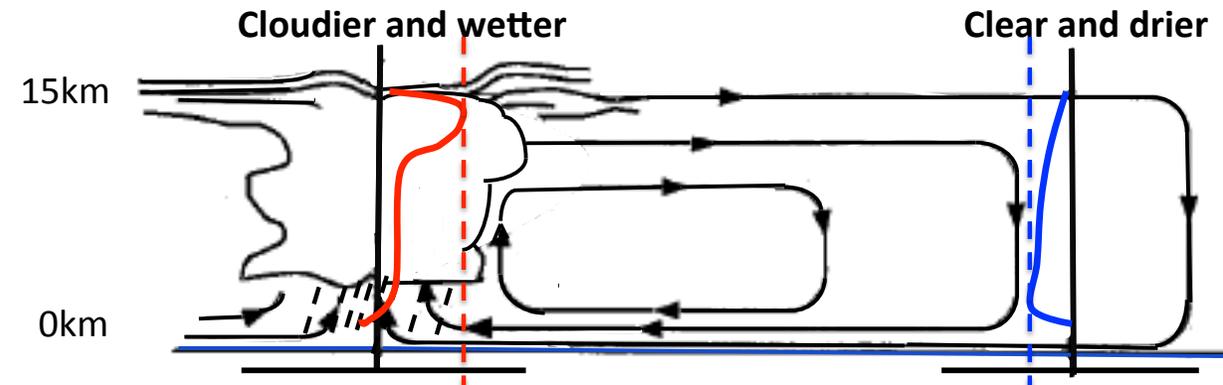


'Measures of the feedback'



Differential heating

Hydrological changes

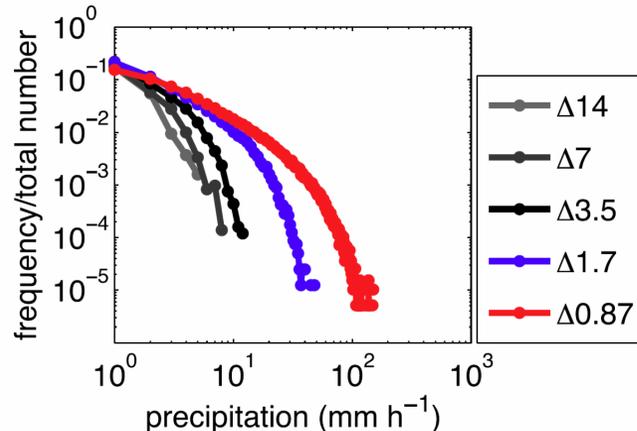
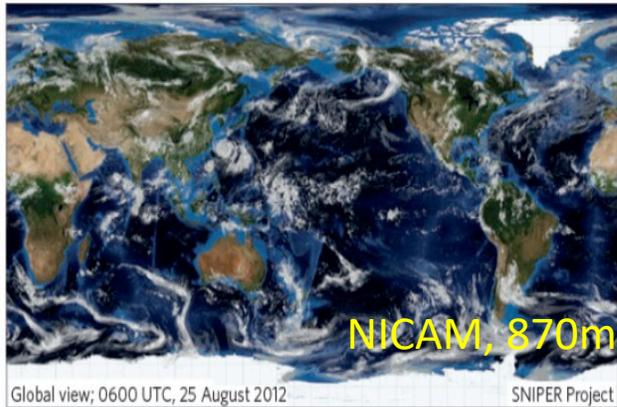


Cloud amount	18%/K	-2%/K
High Cloud amount	15%/K	-8%/K
Cb/CA	5%/K	-3%/K
Ci/CA	7%/K	-4%/K
thinCi/CA	-10%/K	4%/K
Cloud LWP	37.1 gm ⁻² /K	-10.3 gm ⁻² /K
Precipitation	2.9 mm.day ⁻¹ /K	-1.3 mm.day ⁻¹ /K
Column WV	9%/K	-5%/K
RH 200-500 hPa	16%/K	-10%/K

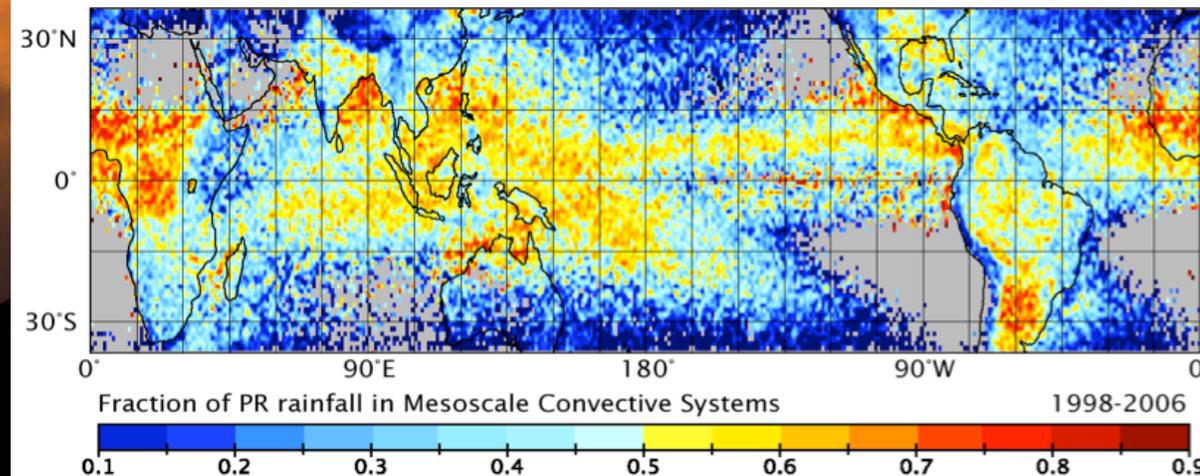
Convection: an Earth system challenge

'Uncertainties surrounding convection and its transports limit our confidence in predictions and thus their value for decision making on all timescales from hours to decades and on all space scales from the local to the global'.

Professor Dame Julia Slingo, Chief Scientist, UK Meteorological Office; 2016 UKMO strategic science plan.



Contribution of MCS
to tropical/mid lat
precip $\sim 70\%$



Observations: initiatives of the coming decade



Earth Obs (EO) Perspective

- Exploiting the new operational observing system - ISCCP next generation major international initiative (GEWEX) - proposing 2km,10minute global spectral record
- US Decadal Survey directions (NASA plans with international partnerships) –aerosol, cloud convection and precipitation (A-CCP)

Our observational challenge is large – we need observe water in all phases and on a vast range of scales and accumulate these on the scale of the whole Earth.

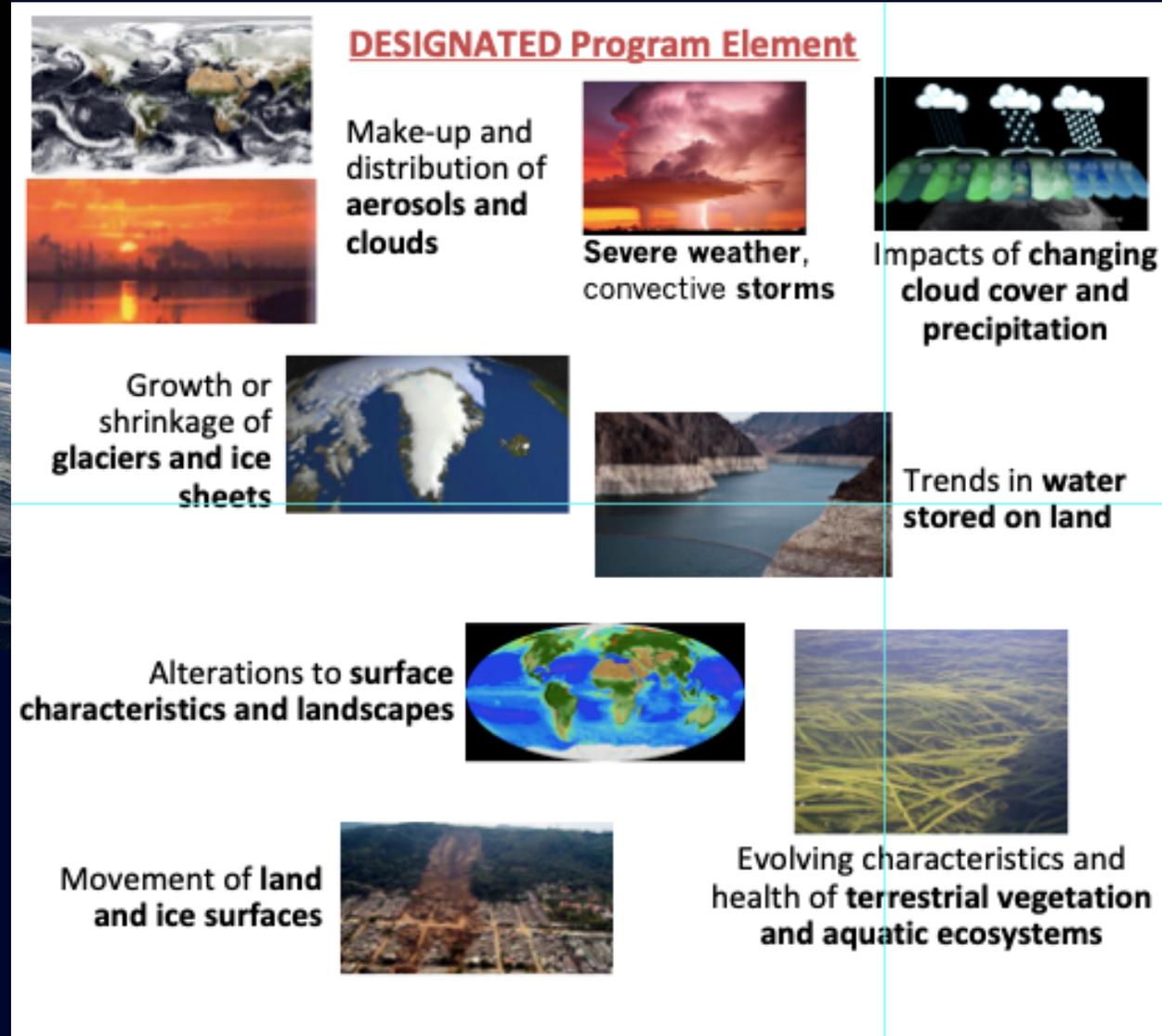


The coming decade (2017-2027)



First designated observables under study

- SBG (surface biology and geology)
- **A +CCP (aerosol+clouds, convection & precipitation - rebuilding the A-Train)**



Concluding slide



8 Science Objectives
Traceable to the 2017 Decadal
Survey MI objectives

**Aerosol Absorption,
Direct & Indirect (7,8)**
Effects on Radiation

Develop and evaluate an integrated Earth system analysis with sufficient observational input to accurately quantify the components of the water and energy cycles & their interactions, and close the water balance from headwater catchments to continental scale river basins ... MI objective of the ESAS Hydrology Panel

A-CCP seek to advance aerosol-moist physics process understanding

**High Cloud
Feedback (2)**

**Convective Storm
Systems (3)**

**Cold Cloud & (4)
Precipitation**

**Mission Study on Aerosol and
Clouds, Convection & Precipitation**