Department of Meteorology

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AIR-SEA FLUXES FROM ATMOSPHERIC REANALYSES

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Thanks to Chunlei Liu, Pat Hyder, Norman Loeb and others

National Centre for Earth Observation
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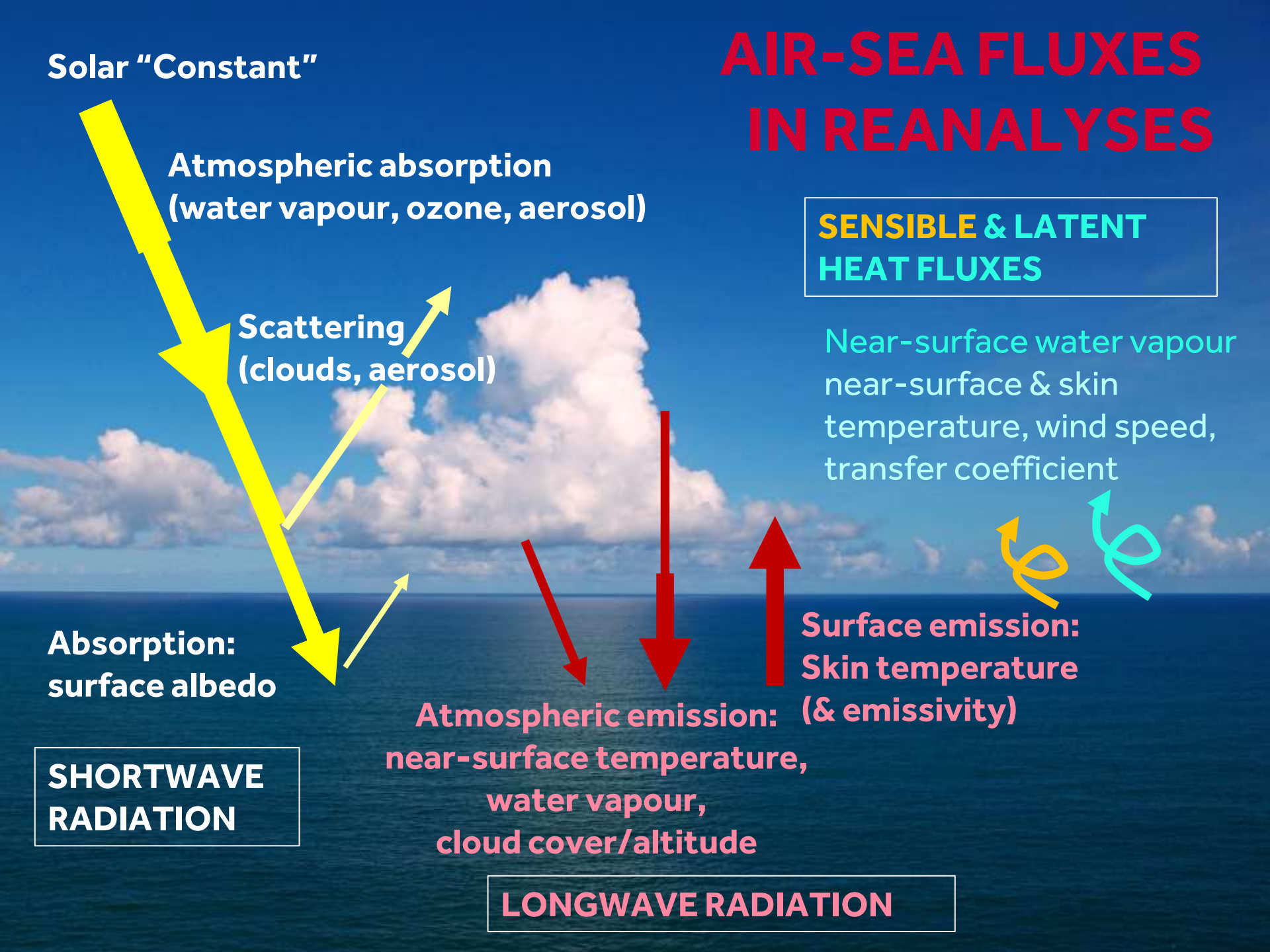
INTRODUCTION

- Are reanalysis air-sea fluxes worth their salt?
- How can we best utilise reanalyses to their strengths?
- Air-sea energy flux magnitudes (e.g. Wild et al. 2015 Clim Dyn):
  - SW 170 Wm^{-2}; LW 50 Wm^{-2}; LH 100 Wm^{-2}; SH 10-20 Wm^{-2}
- Considerable range across reanalysis/observational products
  - e.g. Josey et al. (2013) in Ocean Circ. & Clim.
  - ~20 Wm^{-2} range but includes compensating errors between components

AIM: Discuss general issues and strengths/weaknesses


AIR-SEA FLUXES IN REANALYSES
Solar "Constant"
Atmospheric absorption (water vapour, ozone, aerosol)
Scattering (clouds, aerosol)
Absorption: surface albedo
SHORTWAVE RADIATION
SENSIBLE & LATENT HEAT FLUXES
Near-surface water vapour
near-surface & skin temperature, wind speed, transfer coefficient
Surface emission: Skin temperature (& emissivity)
Atmospheric emission: near-surface temperature, water vapour, cloud cover/altitude
LONGWAVE RADIATION

TURBULENT FLUXES

- Parametrized:
  - Assimilation of water vapour, temperature and wind
  - Interpolation over lower atmospheric layers important
  - Turbulent exchange coefficient and skin properties depend on surface type and atmospheric stability

Turbulent exchange coefficient

Temperature gradient

$$H_S = \rho_a |U_L| C_H (c_p [T_L - T_s] + g z_L)$$

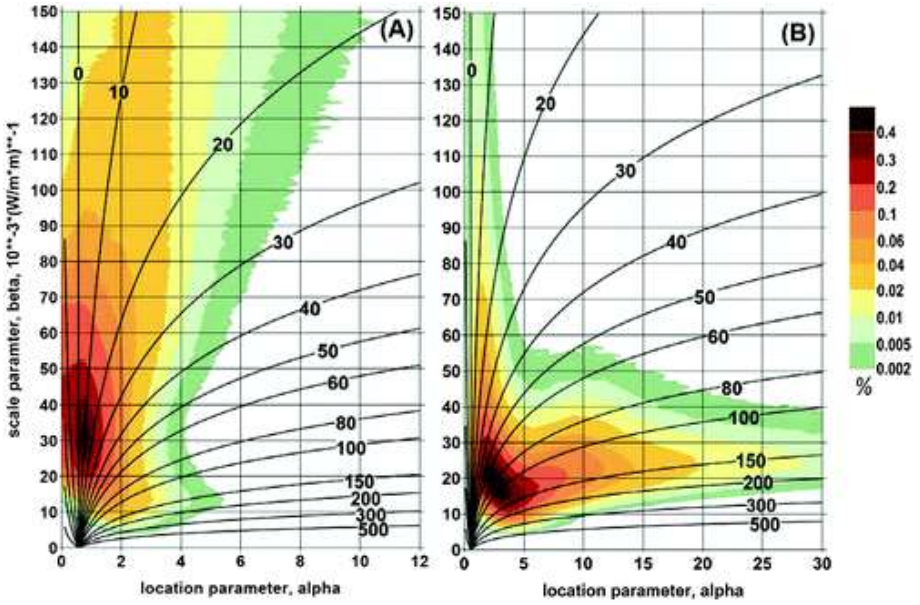
$$H_l = \rho_a |U_L| C_H [q_L - q_{sat}(T_s)]$$

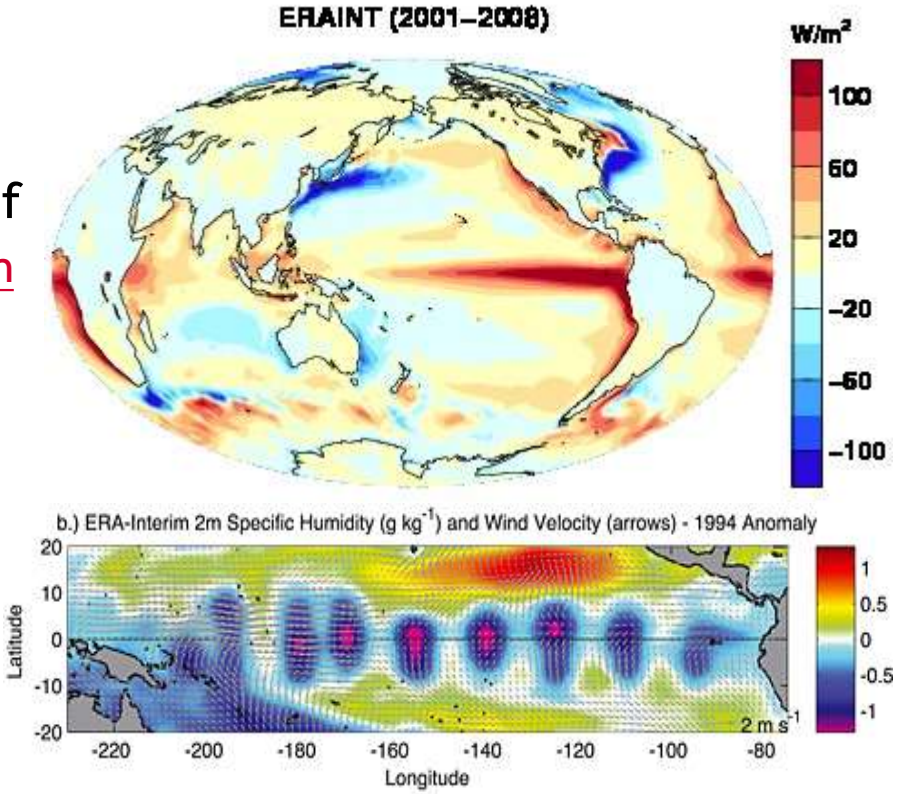
Wind speed

Specific humidity gradient

CLIMATOLOGY, BIASES & EXTREMES

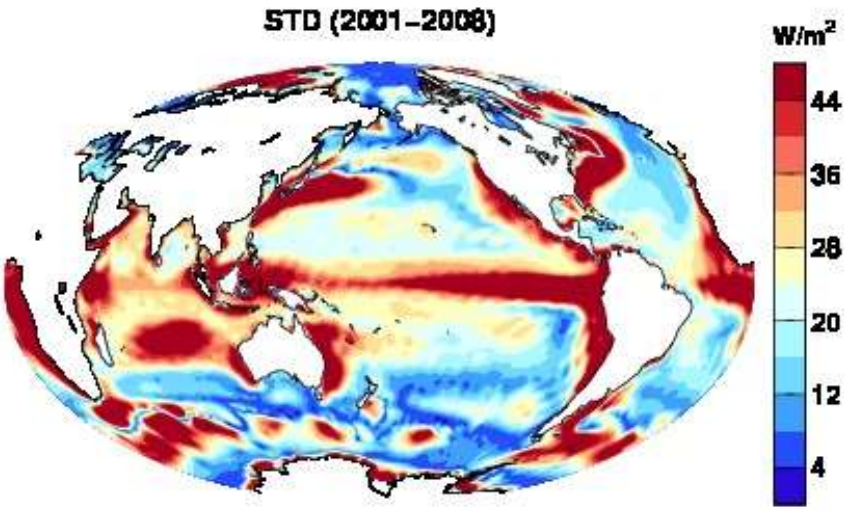
- Climatological biases related to realism of determinent variables
- Climatologies hide characteristics of extremes e.g. Gulev et al. (2013) J. Clim

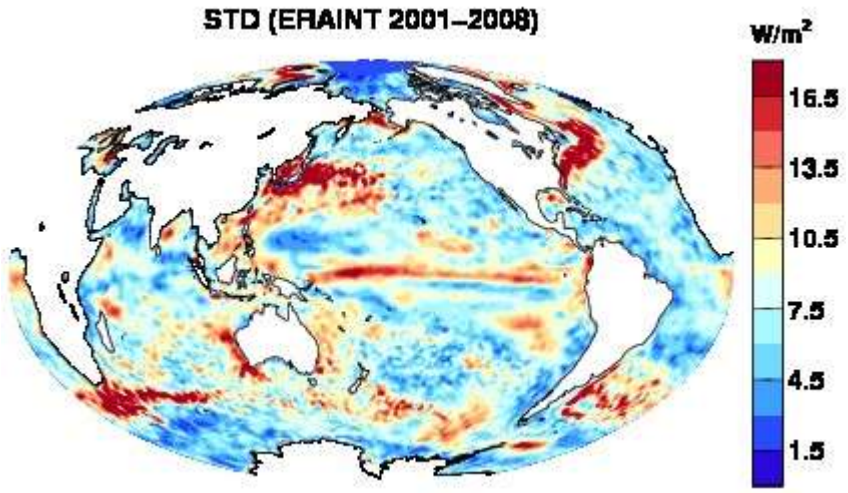




Observing system artifacts:
e.g. Josey et al. (2014) GRL

INTER-REANALYSIS UNCERTAINTY





Standard deviation of multi-annual mean net surface flux (ERAINT, ERA20C, 20thCR, JRA55 and MERRA).

What about interannual variability?

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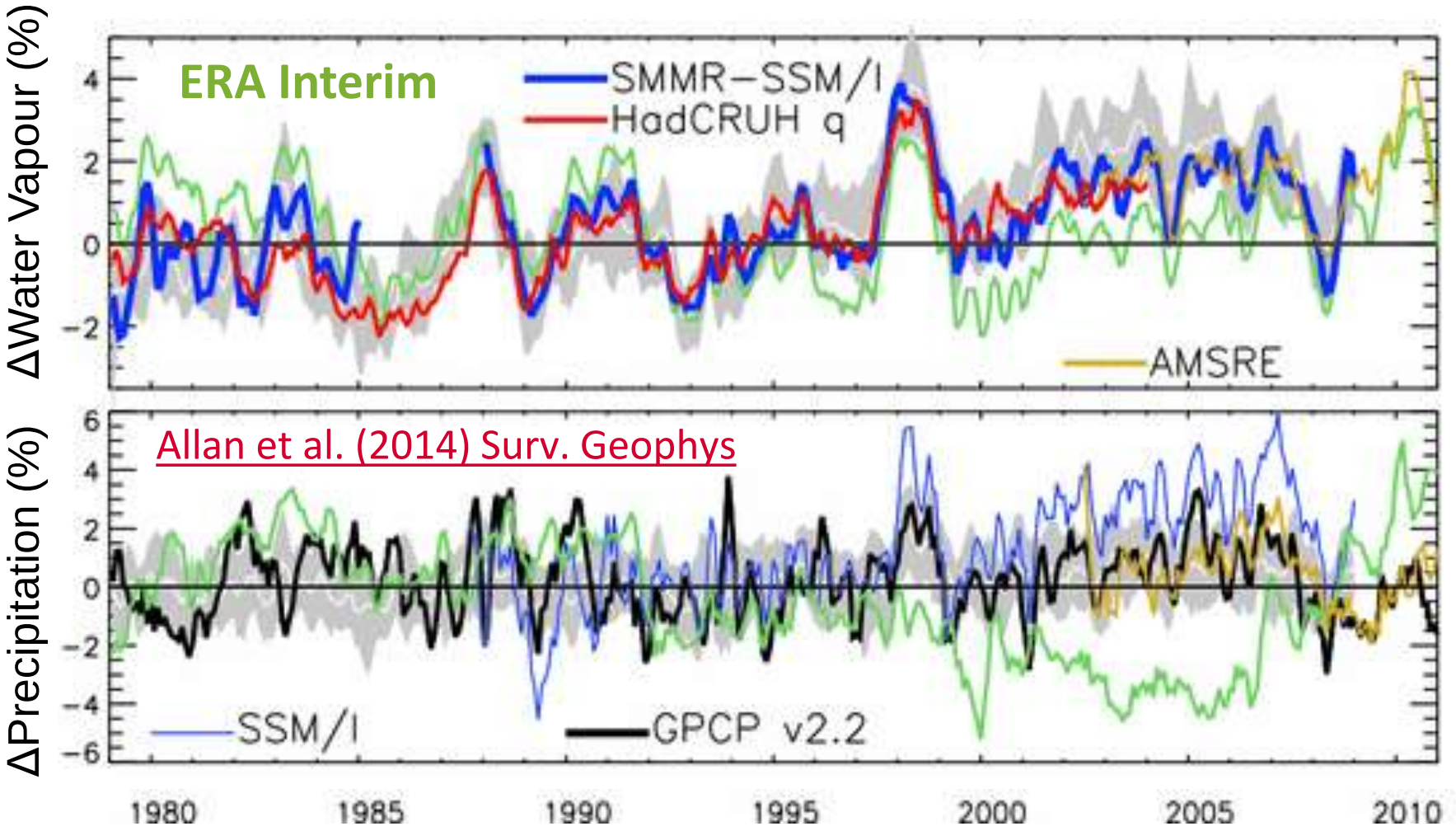
TRENDS IN REANALYSES



See also e.g. Dee et al. (2011) QJRMS, Trenberth et al. (2001) J. Clim

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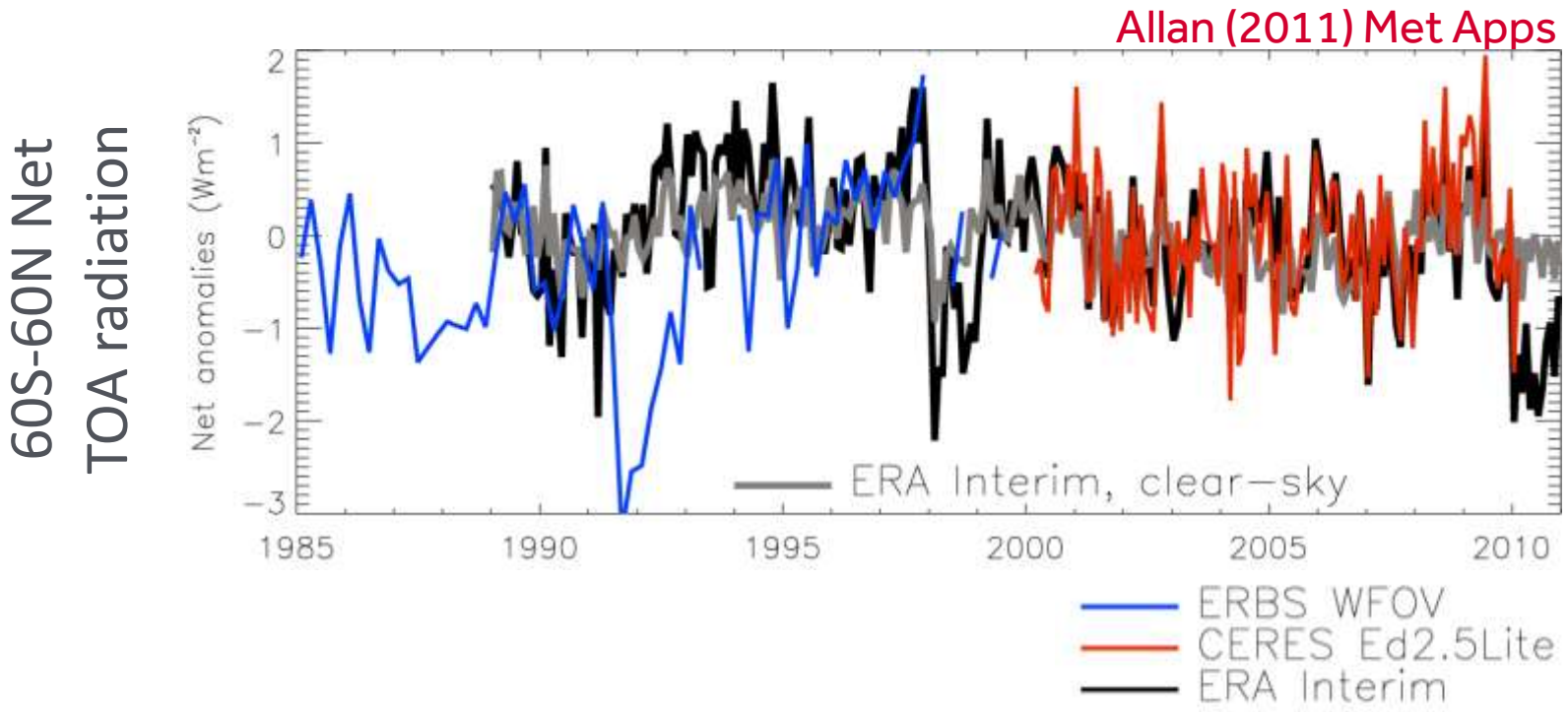
MONTH-TO-MONTH VARIABILITY

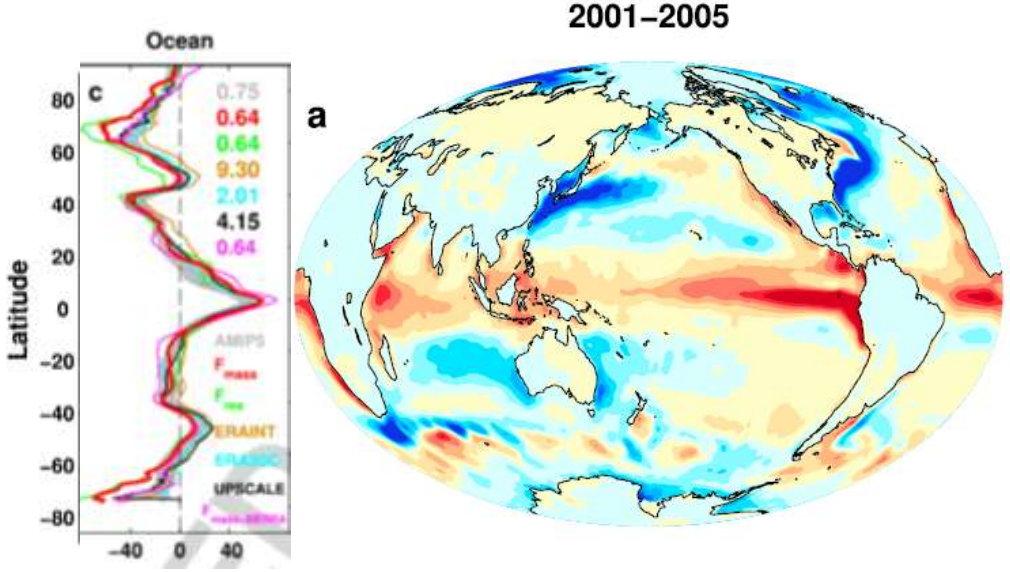
Allan (2011) Met Apps

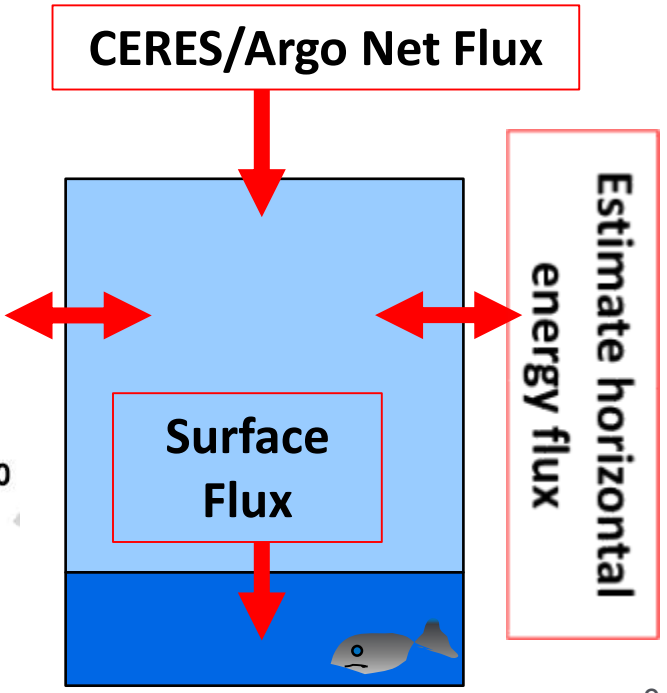


ERA Interim: suspect energy and water cycle climatology & trends *but* realistic variability in clouds and non-aerosol atmospheric properties

INDIRECT ESTIMATES OF AIR-SEA ENERGY FLUXES FROM SATELLITE/REANALYSES

$$F_{SFC} = F_{TOA} - \frac{\partial TE}{\partial t} - \nabla \cdot \frac{1}{g} \int_0^1 V(Lq + C_p T + \varphi_s + k) \frac{\partial p}{\partial \eta} d\eta$$



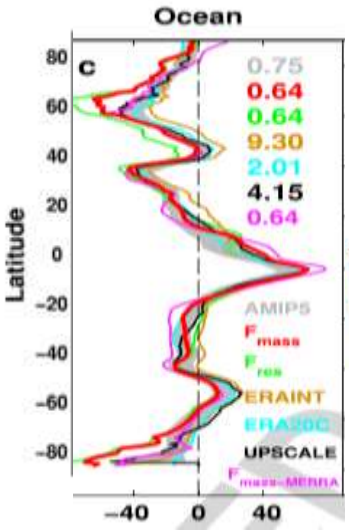


Net surface downward energy flux (Wm^{-2})

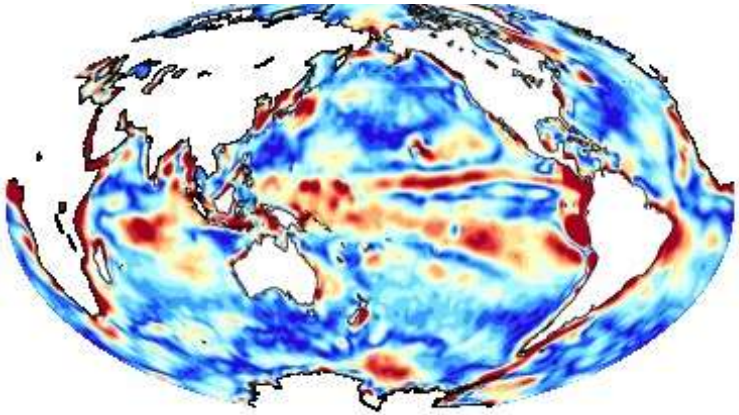
Liu et al. (2015) JGR, Allan et al. (2014) GRL

see also Loeb et al. (2015) Clim. Dyn , Trenberth et al. (2001) Clim. Dyn.

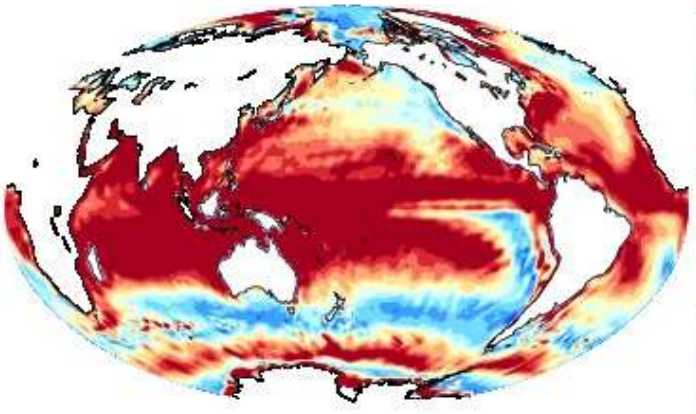
HOW UNCERTAIN ARE DIRECT/INDIRECT SURFACE ENERGY FLUX ESTIMATES?



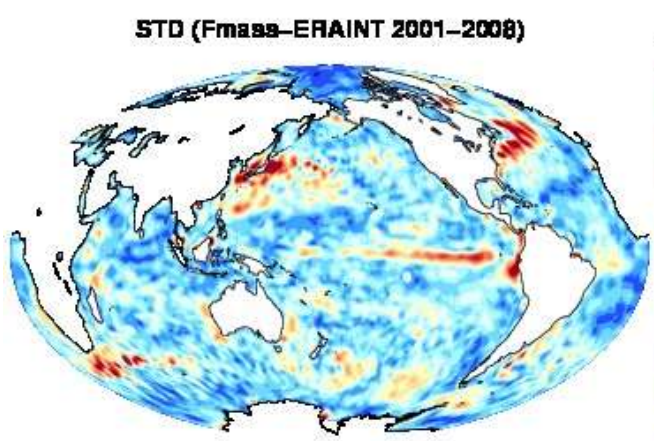
StDev indirect (3)

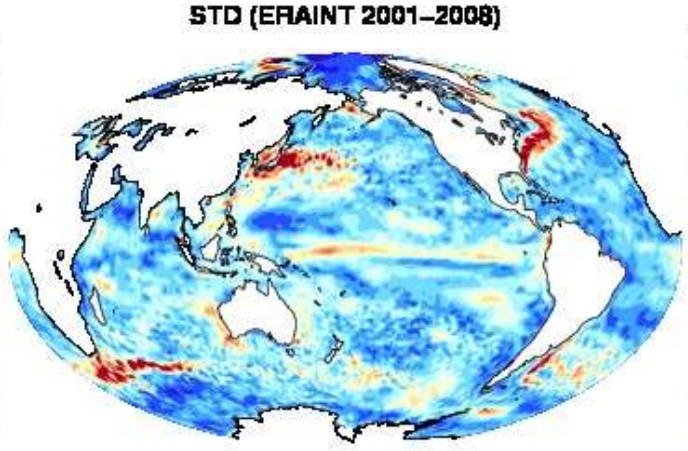


StDev Direct (5)

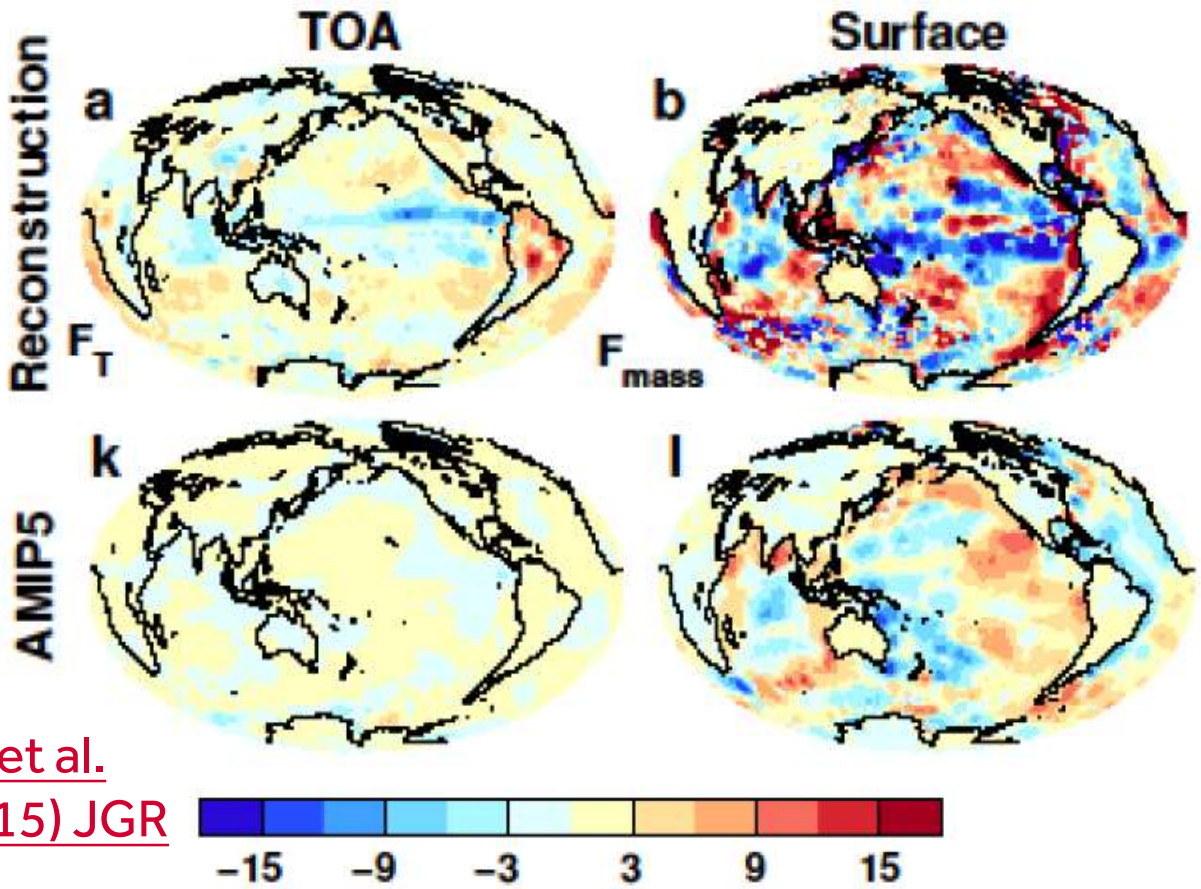


Climatology (above), Interannual variability (below)



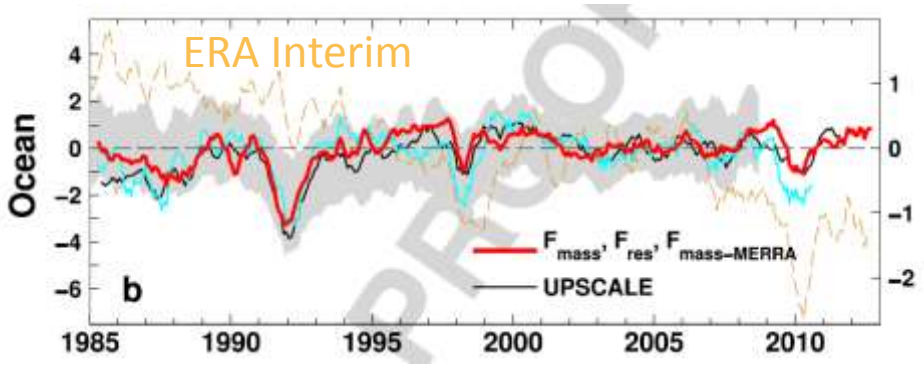


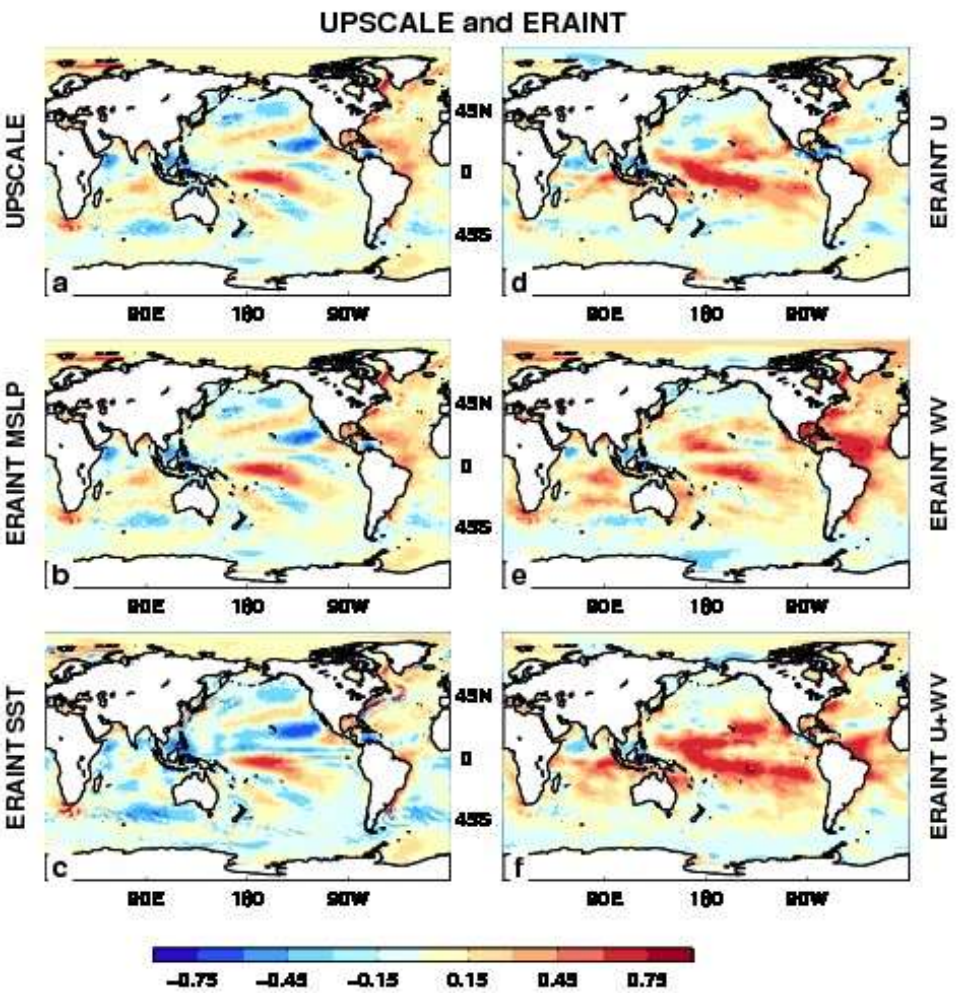
CHANGES IN SURFACE ENERGY FLUX



- Changes in energy fluxes 1986-2000 to 2001-2008
- Surface energy flux dominated by atmospheric transports
- Contrasting model pattern of change
- Are reanalysis transports reliable?

Liu et al. (2015) JGR





UNDERSTANDING DISCREPANCIES

- Spurious trends in air sea fluxes in ERA Interim
- Dominated by latent heat fluxes
- Use simple bulk formula model to understand causes of differences with other reanalyses & models

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CONCLUSIONS

- How can we best utilise information from reanalyses to improve understanding of air-sea fluxes?
- **Strengths:** good coverage in space and time (sparse in situ observations), links to determining variables, observationally-based, reasonable month to month and regional interannual variability
- **Weaknesses:** dependence on model-based parametrizations, require interpolation of variables in lowest layers, observing system artifacts in space and time, moisture and energy budget's not closed
- Indirect methods for constraining surface energy and moisture fluxes promising as complimentary method