Tier1b diagnostics: the global water cycle in ACME

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Motivation

For Tier 1b global water diagnostics:

We would like the ACME model to provide an accurate representation and prediction of the water cycle so that we may predict future changes in water resources

Approach

Given the motivation, the goals of the diagnostics are to:

Concisely assess whether ACME's atmosphere model can correctly represent the "main features" of the water cycle

Make use of the best available observations and use known constraints of the water cycle (look under Obs dataset in **Table 1**)

Examine source (evaporation), sink (precipitation), reservoir (precipitable water), and flow (transport) of water

The "main features" we examine are the mean, spatial distribution, and rain rate distribution.

Water budget equation helps connect spatially varying fields of precipitation, evaporation, and water vapor transport in **Fig. 2, 3, 4**. E.g. the strong precipitation over Pacific ITCZ is likely related to strong gradient in water vapor transport.

$$\frac{dW}{dt} = E - P - \nabla \int_0^{p_0} q\vec{v}\,\frac{dp}{g}$$

Change in precipitable water; Precipitation; Evaporation; Divergence of water vapor transport

Energy budget equation connects the strength of the water cycle (LHF) to the atmospheric energy budget in **Fig. 1**. E.g. if we find that the water cycle is too strong in the model, we can diagnose whether other energy budget terms lie outside of observed uncertainty.

$$\frac{dE_a}{dt} = R_{TOA,\downarrow} + R_{surf,\uparrow} + LHF + SHF$$

Change in global atmospheric energy; Net radiation downward at top of atmosphere; Net radiation upward at surface; **Latent heat flux**; Sensible heat flux

Table 1: Set of diagnostics currently under development for assessing the global water cycle.

Diagnostic	Rationale	Variables	Obs dataset
Atmospheric energy budget terms	Constrained by the global energy budget	FSNT, FLNT, FSNS, FLNS, SHFLX, LHFLX	Published energy budget assessments (see Fig. 1)
Land/ocean P, E, transport	Quick comparison determines land/ocean partitioning	PRECT, QFLX, LANDFRAC	Trenberth et al. 2007
Global precipitation rate	Compare spatial distribution	PRECT	GPCP
Global evaporation rate	Compare spatial distribution	QFLX	LandFlux, COREV2
Global precipitable water	Compare spatial distribution	TMQ	NVAP
Water transport	Water transport connects E with P	TUQ, TVQ	ERA-Interim reanalysis
Water vapor lifetime	Provides quick ratio of reservoir/sink	TMQ,PRECT	NVAP, GPCP
Precipitation rate frequency distribution	Quick look at frequency of different precipitation rates	PRECT, PRECC	GPCP_1DD (PERSIANN likely used in future)
Precipitation rate amount distribution	Quick look at amount of different precipitation rates	PRECT, PRECC	GPCP_1DD (PERSIANN likely used in future)

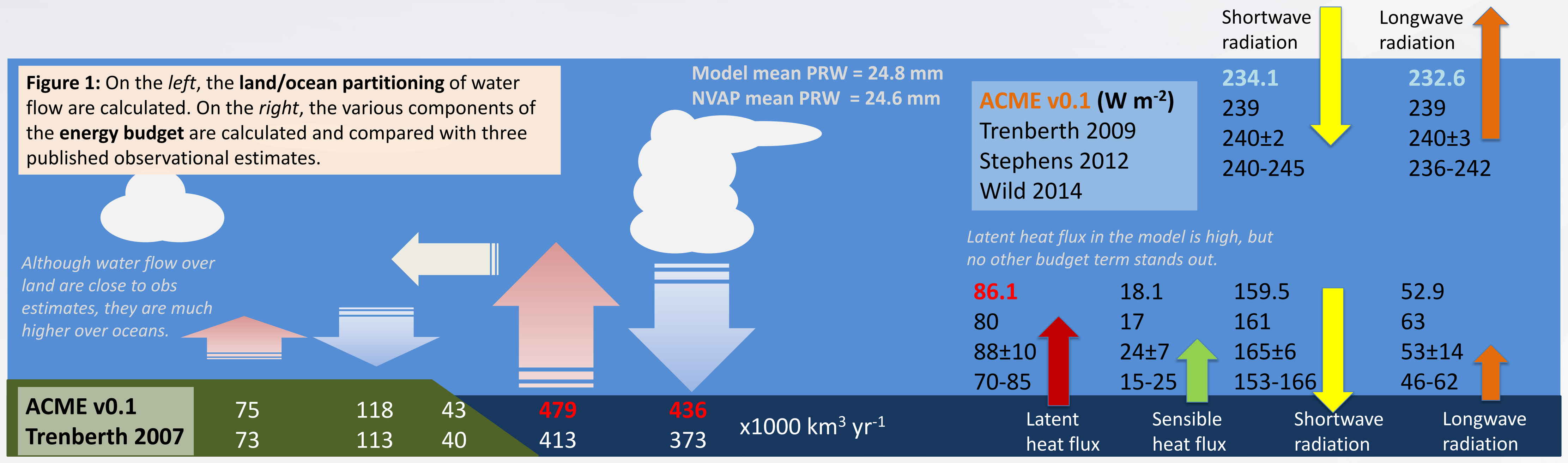
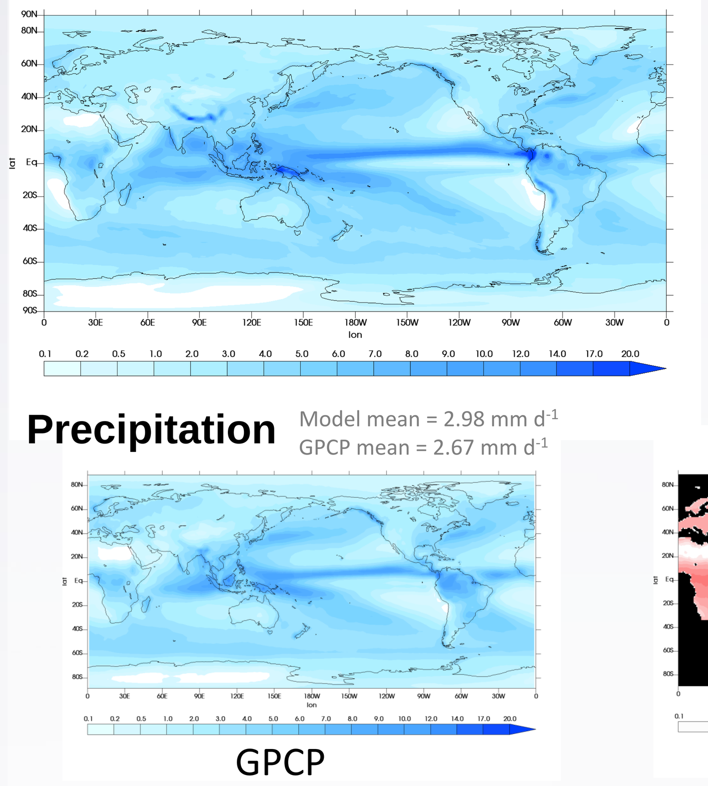


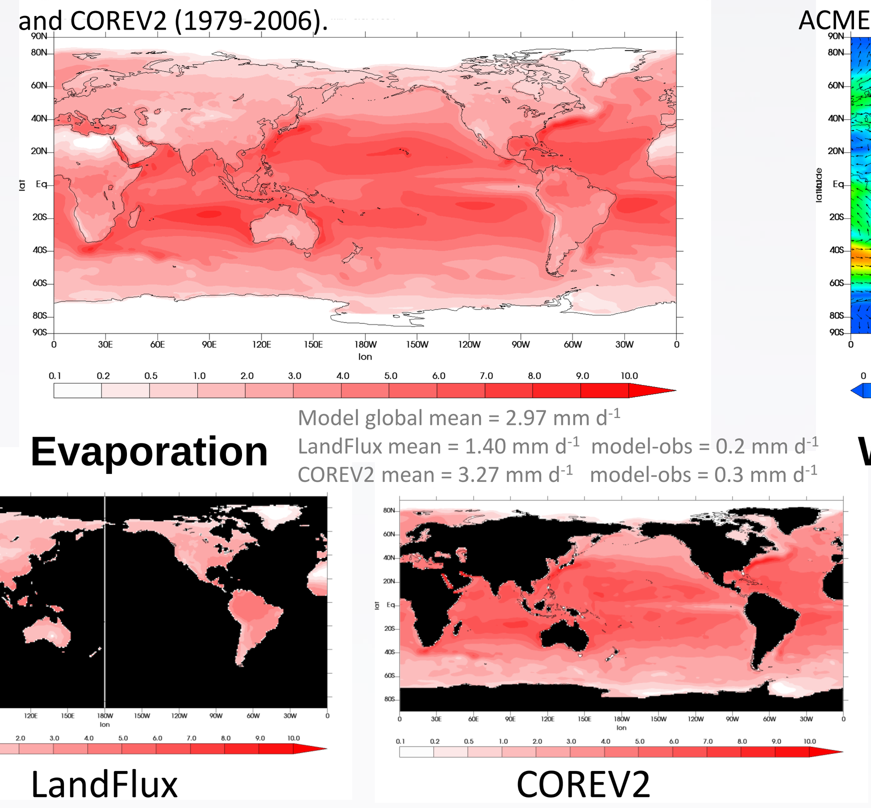
Figure 1: On the *left*, the **land/ocean partitioning** of water flow are calculated. On the *right*, the various components of the **energy budget** are calculated and compared with three published observational estimates.

Figure 2: Precipitation in ACME v0.1 and GPCP (1979-2009).



→ *Model captures overall pattern, but mean is considerably higher than GPCP, especially evident over ITCZ and over mountains.*

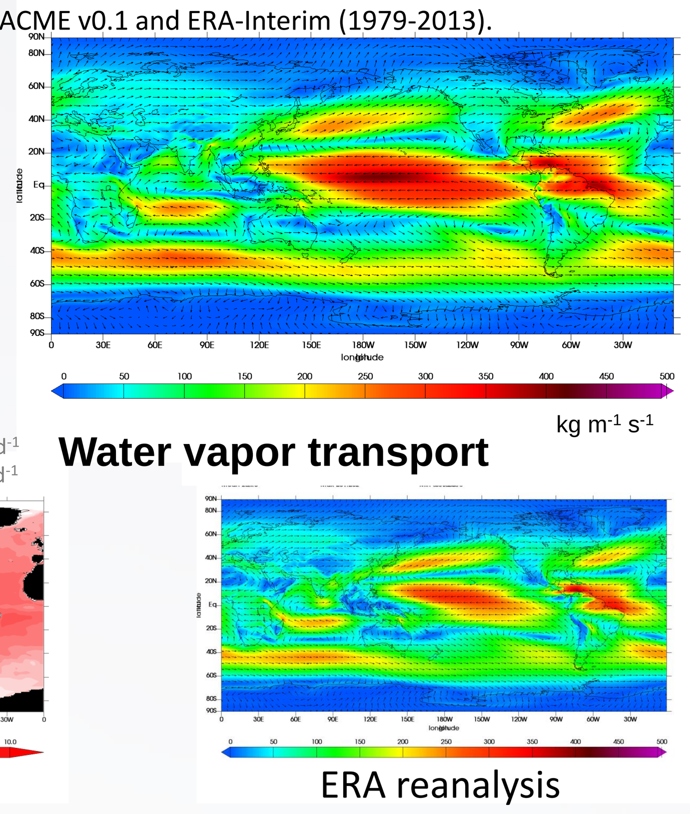
Figure 3: Evaporation in ACME v0.1, LandFlux (1989-2006), and COREV2 (1979-2006).



→ *General agreement between model and LandFlux with discrepancies over Amazon and SEAsia.*

→ *General agreement between model and COREV2 estimates, although differences arise over subtropics.*

Figure 4: Vertically integrated water vapor transport in ACME v0.1 and ERA-Interim (1979-2013).

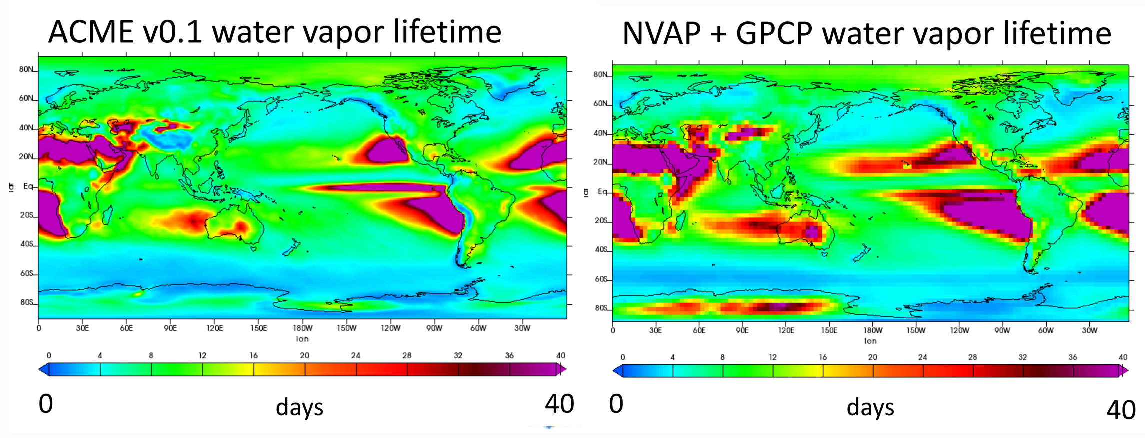


→ *Same overall pattern, but stronger transport in ACME v0.1.*

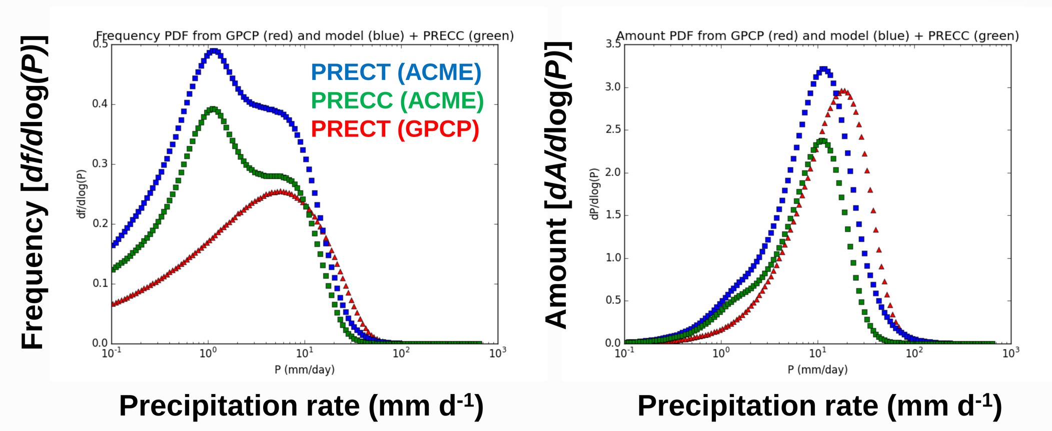
Impact

Results:

Water cycle in ACME v0.1 is "too active"



There is too much drizzle in the model (most of it from convective precipitation)



Remaining questions & future plans:

Are we using the *same observational datasets* to constrain across different spheres/components of ACME?

What is the best way to *show uncertainty* in observational datasets (e.g. 'observed' ocean evaporation)?

Diagnostics can be found on the confluence website by searching '**tier 1b global water cycle**' or by typing: https://acme-climate.atlassian.net/wiki/display/ATM/Tier+1b+metrics%3A+Water+cycle+diagnostics

ACME Accelerated Climate Modeling for Energy

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