Multiscale Land-Atmosphere Coupling in a Tropical Environment

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The Basic Idea

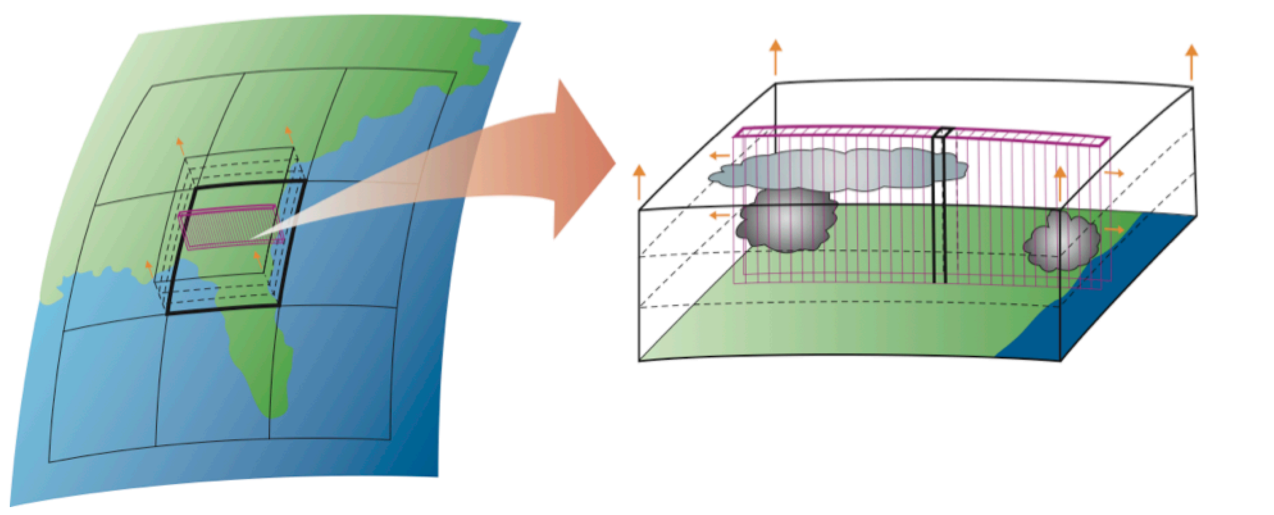
- AGCMs are incorporating multiscale techniques, where a cloud-resolving model (CRM) is embedded within a gridcell (Figure 1)
- AGCM sends advective forcing to the CRM, which provides heating and drying

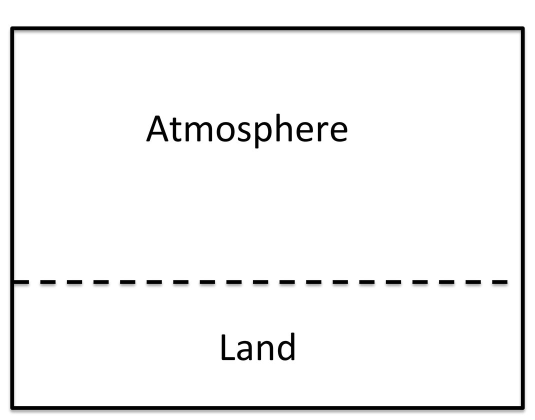
BUT…

- We are unaware of differences in the coupled land-atmosphere behavior imposed by different configurations (See Figure 2)

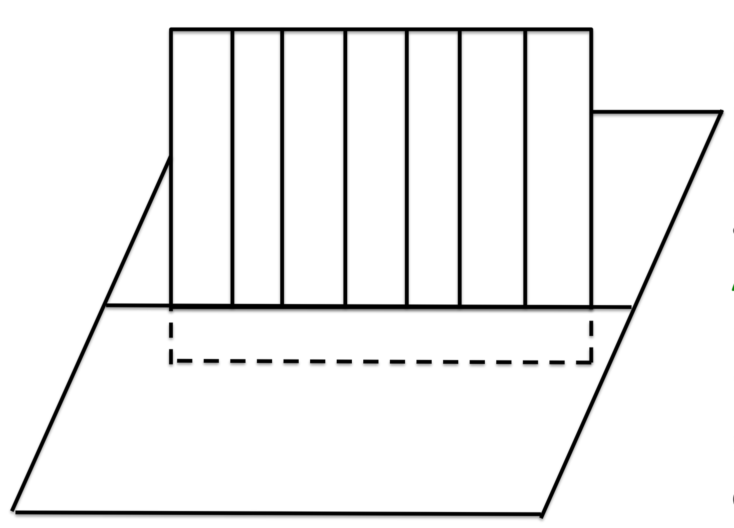
What We've Done

- We performed Single-Column Model (SCM) simulations at a tropical forest and evaluated differences in surface and atmospheric behavior

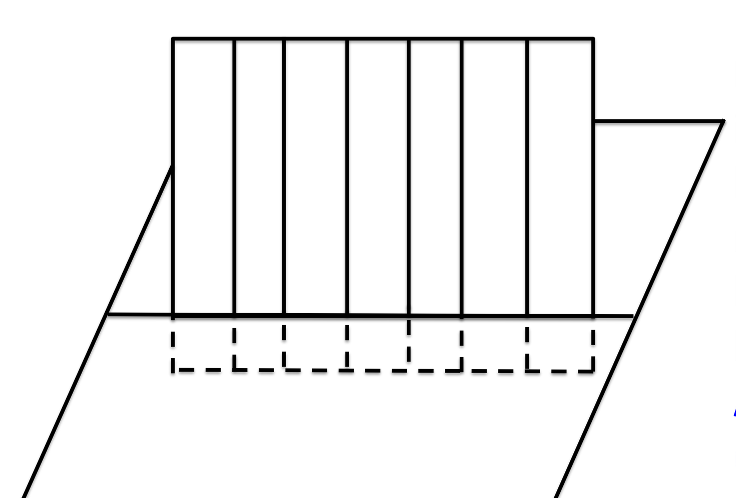




Traditional AGCM: Parameterized, **Single Atmosphere** coupled to a **Single Land (SASL)**. Simulations described in Harper et al., (2010).



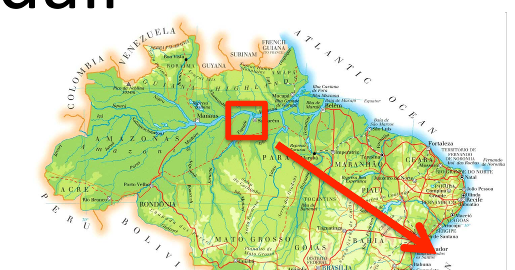
Domain-averaged CRM behavior (precipitation, radiation) passed to a single land module (Khairoutdinov and Randall, 2003). **Multiple Atmosphere, Single Land (MASL)**. Current 'superparamterized' models (e.g. SP-CESM) use this configuration

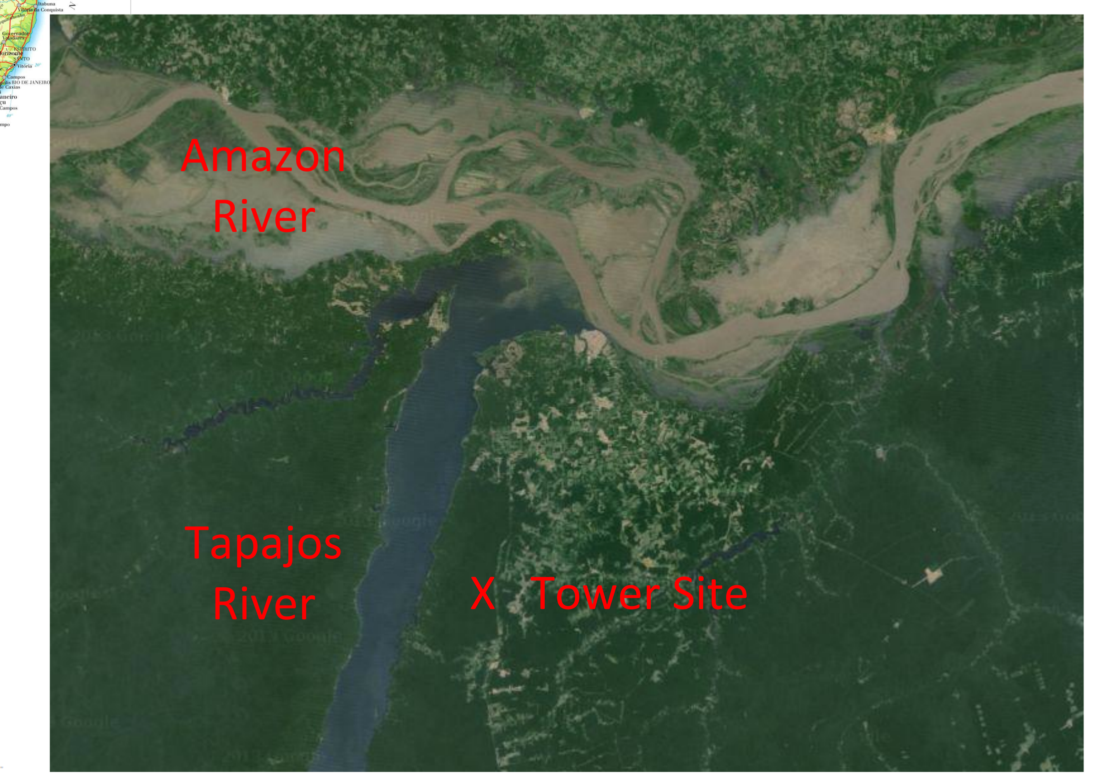


Each CRM element coupled to its own land module; allows heterogeneity in precipitation, radiation, surface moisture to be communicated between land and atmosphere. **Multiple Atmosphere, Multiple Land (MAML)**

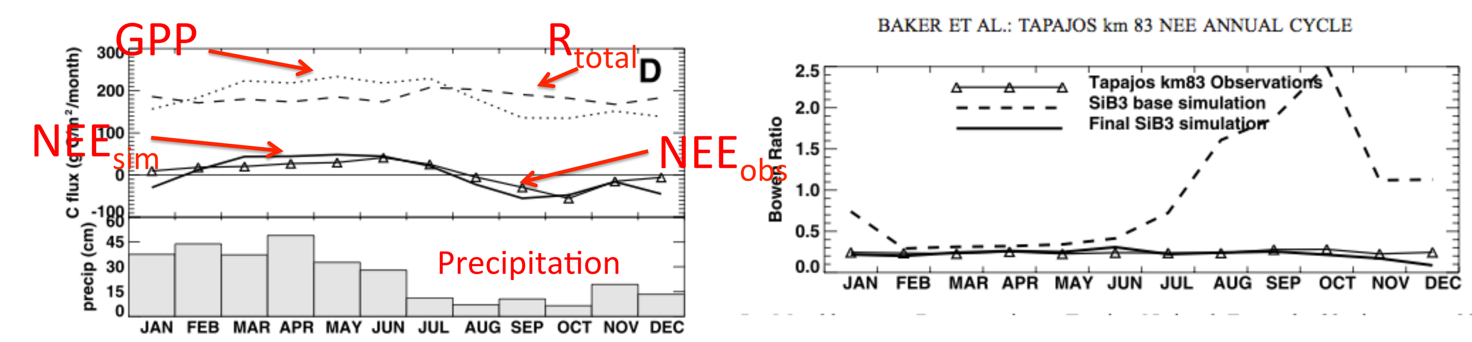
Figure 2

Site: Tapajos National Forest Km83, Brazil





- Tropical Forest, described by Goulden et al. (2004), Miller et al. (2004), da Rocha et al. (2004)
- Simulated ecophysiology described in Baker et al. (2008), Baker et al (2013)
- Surface behavior coupled to SCM described in Harper et al. (2010)



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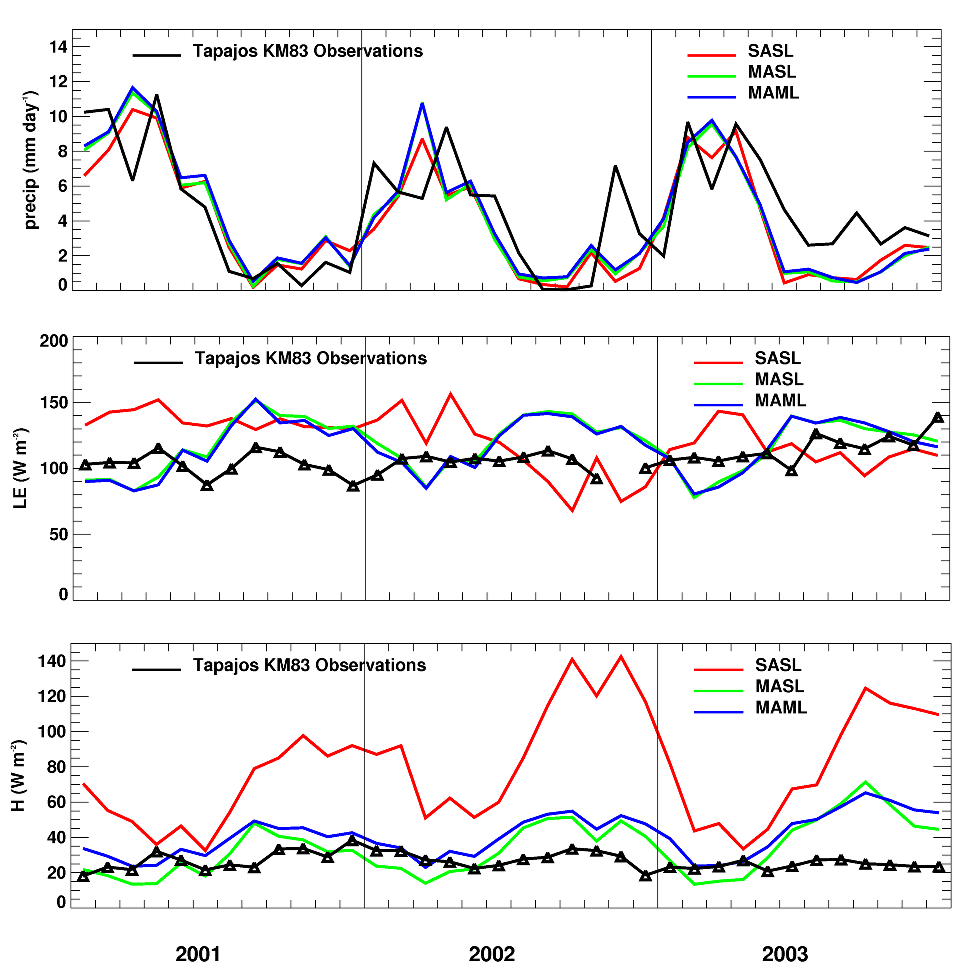
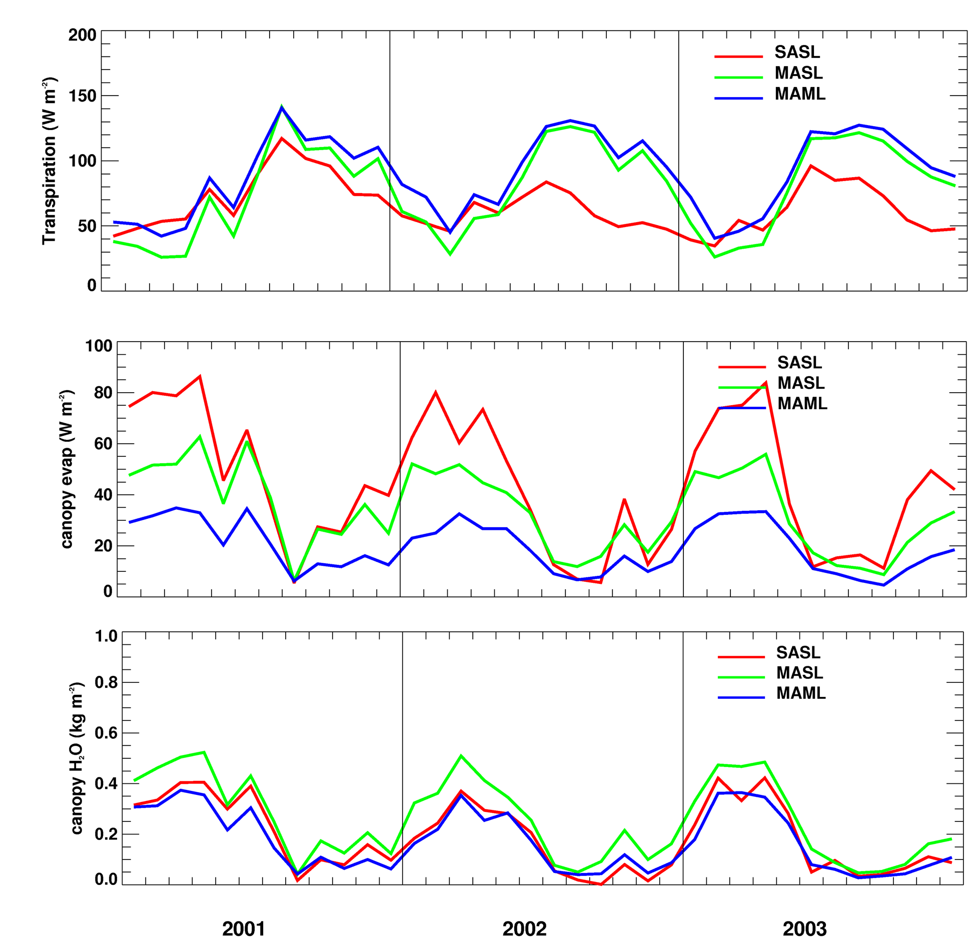
Precipitation, H, LE



Precipitation
- All models have reasonable magnitude/seasonality
- No diurnal temporal difference between models
- MAML has largest magnitude (heavy rain in a few CRM columns)

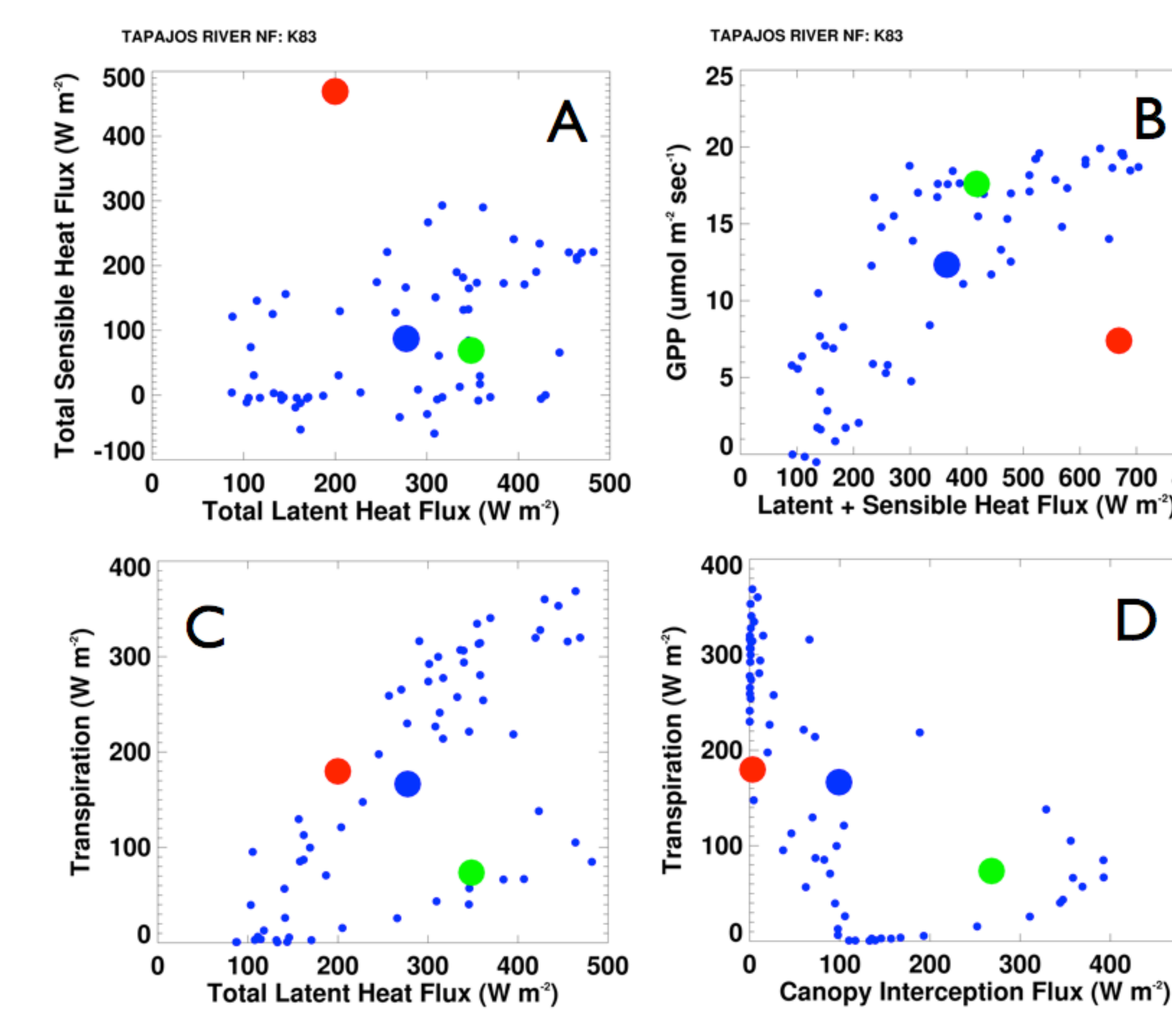
Energy/Moisture flux
- SASL: Bowen ratio too high, especially in dry season
- MASL/MAML very similar

Evaporation Components



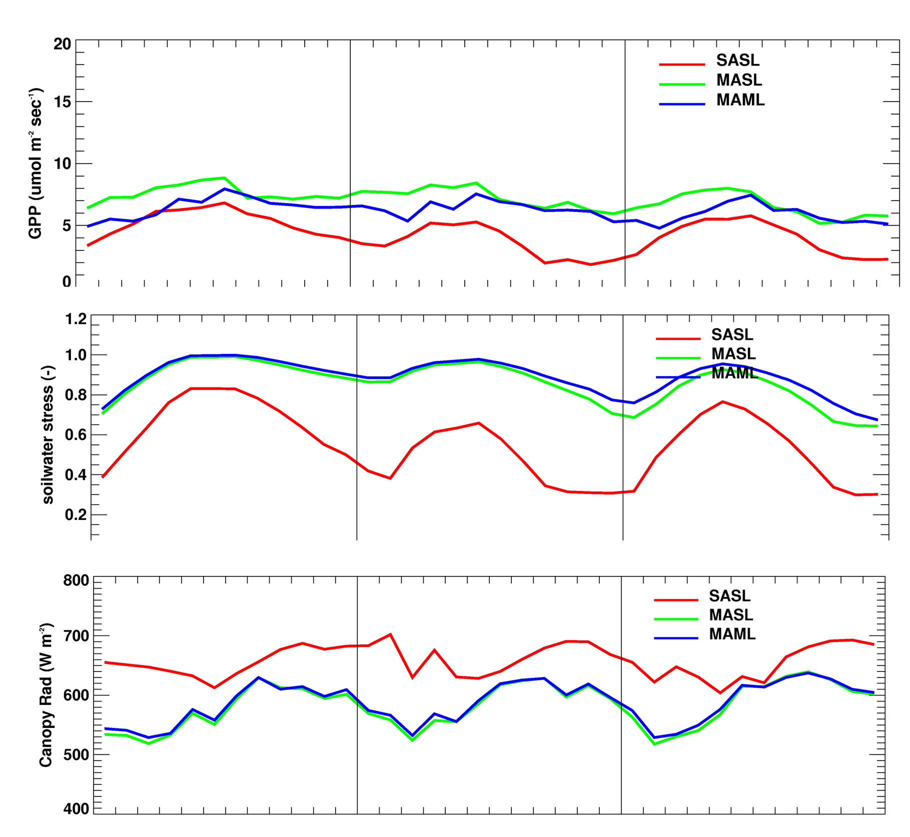
- Larger partition towards transpiration in MASL/MAML
- More canopy water (leaf sfc) in MASL, more of it evaporates in SASL

Single-Time Snapshot: 1400 LST 03 Jan 2002



- Largest H+LE in SASL; cloudy CRMs bring down radiation in SASL/MASL
- Bowen ratio large in SASL (larger Rnet, more stress)

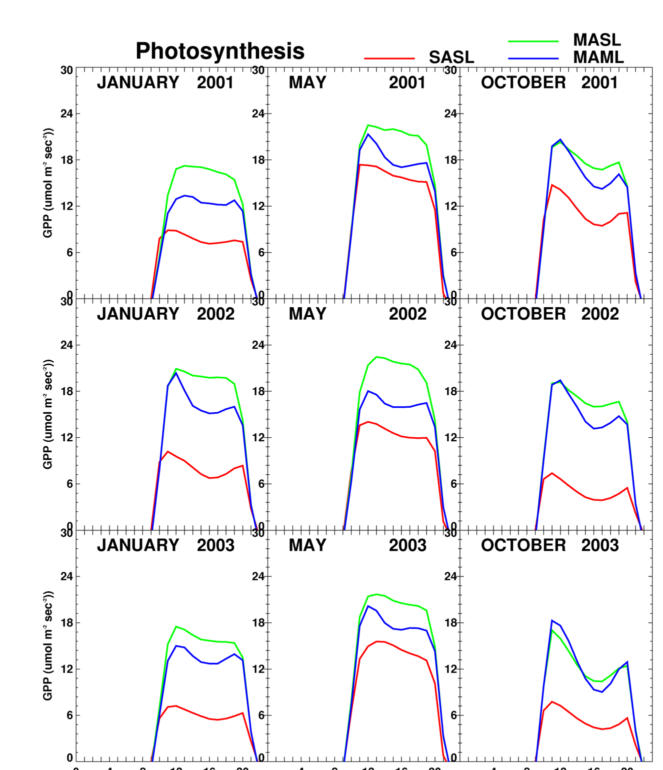
Carbon Cycle



SASL:
- Greater insolation into canopy; imposes greater transpiration load and soilmoisture stress
- Wet season (January); GPP is light-limited
- Dry season (October); soil moisture and temperature/humidity stress

MASL:
- Largest GPP of the 3 models
- Diurnal: CRM-mean forcing 'smooths' canopy-atmosphere interaction (cloudy/dark, clear/hot)

MAML:
- Peak AM GPP similar to MASL
- Midday suppression in clear/hot CRM elements. Cloudy CRM elements are very dark (insufficient diffuse)



What have we learned?

- Large-Scale precipitation similar between the 3 models
- Energy Budget (R_{net}, H, LE) vastly different between SASL and either CRM-level coupling (MASL, MAML), which are both more realistic
- Further differences in carbon cycle arise between MASL/MAML due to heterogeneity in transpiration, canopy evaporation, runoff
- High-amplitude events result in different LE partitioning in MAML

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