Perturbed-Physics Experiments with CICE running with CAM4 + Slab Ocean Model

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… and showing results from:

- Scott Brandon (LLNL Weapons and Complex-Integration)
- David Domyancic (LLNL Computing / Applications, Simulations and Quality Division)
- Gardar Johannesson (LLNL National Security Engineering Division)
- Steve Klein (LLNL PCMDI / Atmospheric, Energy and Earth Division)
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- Donald Lucas (LLNL Atmospheric, Energy and Earth Division)
- John Tannahill (LLNL Global Security Computing)
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NB: Sea ice results are very preliminary – runs still in progress. All opinions herein are Curt's, not necessarily everyone's in the project.

Summary of Perturbed-Physics Experiments with CAM4 run in AMIP Mode*

- 28 uncertain input parameters identified ("expert elicitation")
- The challenge: if we consider 3 possible values for each,

$$3^{28} = 22,876,792,454,961 > 2 \times 10^{13}$$

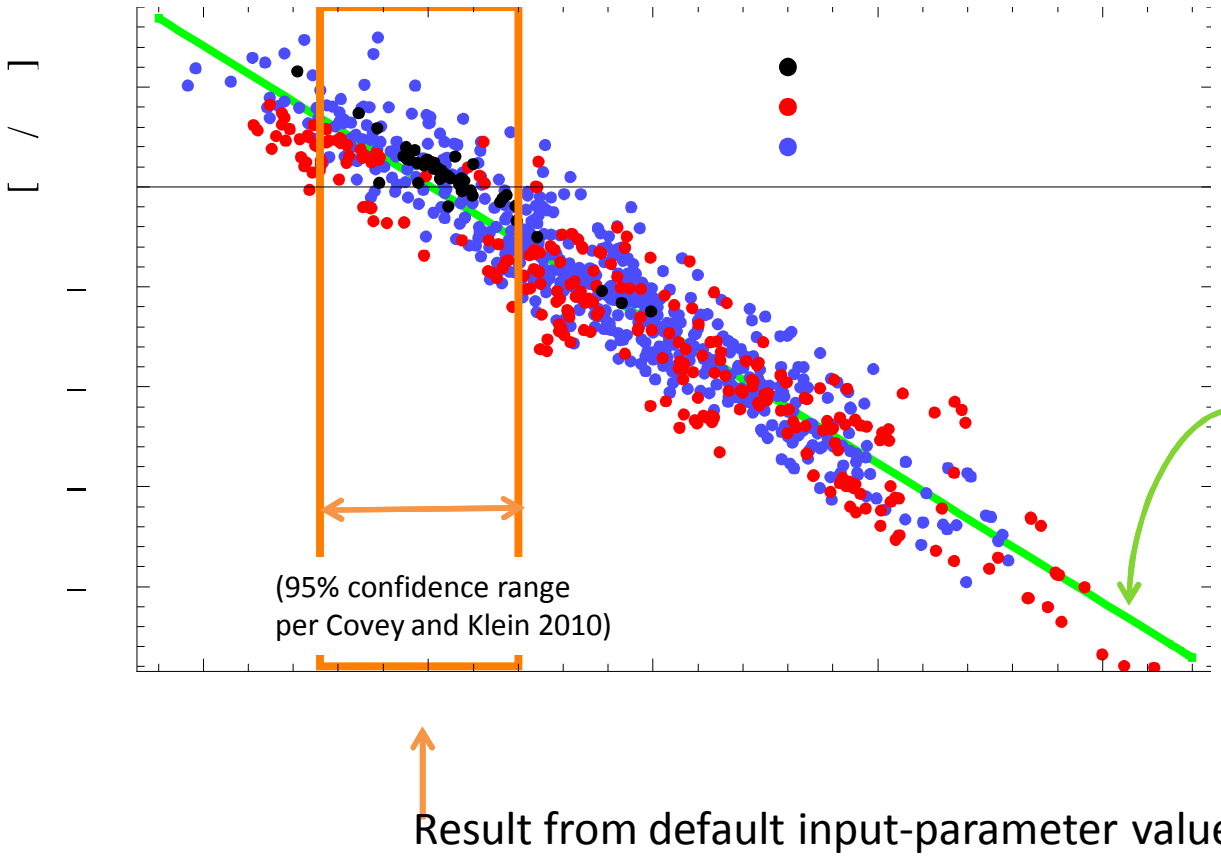
- How to sample? Choice of input-parameter variations? See AMWG and Breckenridge talks by Lucas, Brandon, Tannahill.
- 2,937 12-year AMIP simulations → 43 Tbytes output
  - Bigger than CMIP3 / IPCC AR4 database of climate model output
  - Needs similar worldwide accessibility to be fully analyzed

* Note earlier PPEs of CAM3 in both AMIP and SOM mode by:

- C. Jackson et al., J Climate 21: 6698 (2008)
- B. Sanderson, J Climate (in press)

Summary of Perturbed-Physics Experiments with CAM4 run in AMIP Mode (continued)

Varying 27 uncertain input parameters:*



r = −0.96
slope = −280 W/m2
intercept = 84 W/m2

*Varying 28 parameters:
r = −0.95
slope = −290 W/m2
intercept = 89 W/m2

Result from default input-parameter values

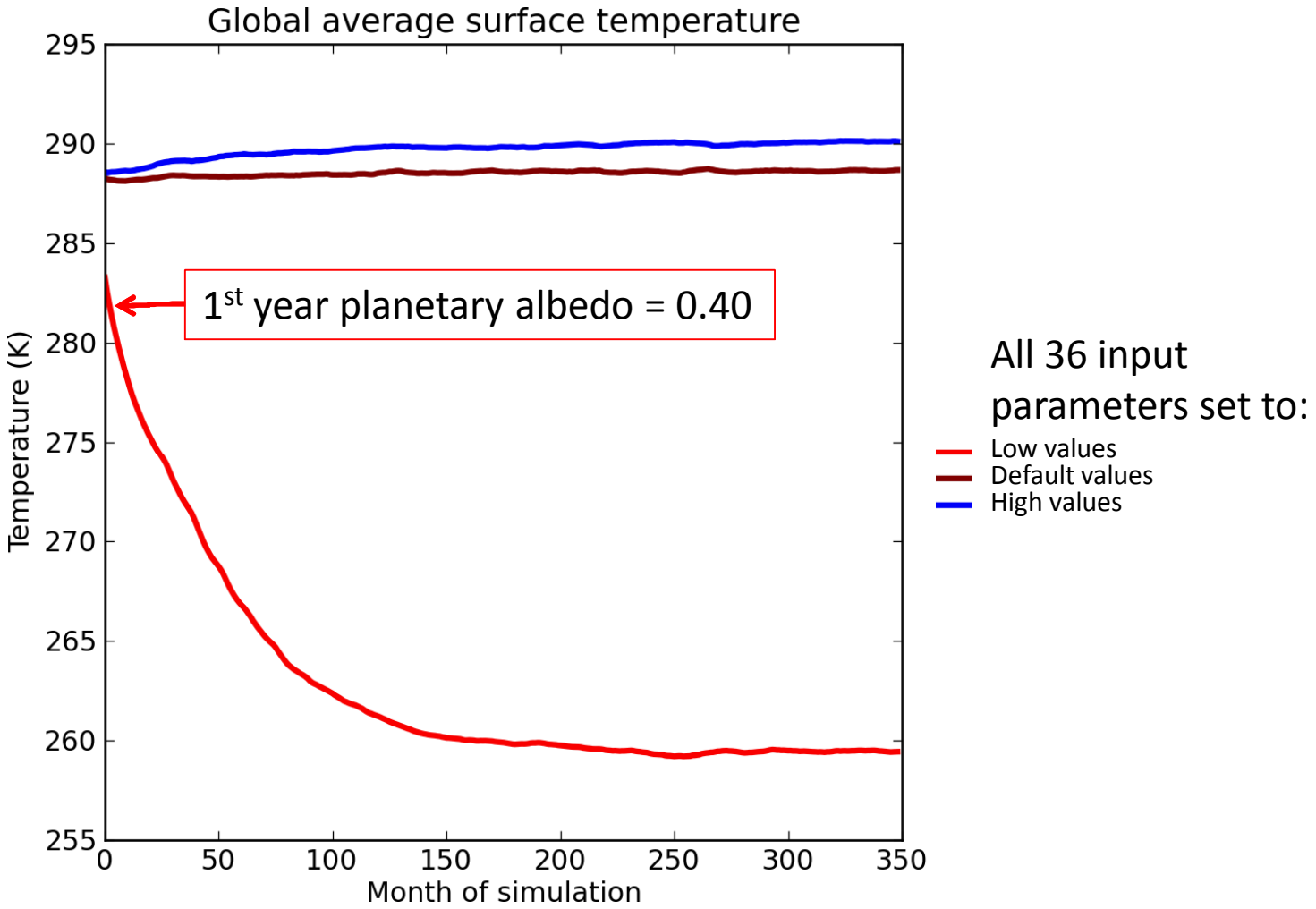
CICE contributes 7 additional uncertain input parameters:

	name	low	default	high	description		.F90 subroutine	
1	dt_mlt_in	**0.10**	**1.50**	**1.80**	**Temperature at which ice melt begins [°C]**		**ice_shortwave**	
2	r_ice	**-1.9**	**0.0**	**1.9**	**Sea-ice albedo tuning parameter [s.d. units]**		**ice_shortwave**	
3	r_pnd	**-1.9**	**0.0**	**1.9**	**Ponded-ice albedo tuning parameter [s.d. units]**		**ice_shortwave**	
4	r_snw	**-1.9**	**1.5**	**1.9**	**Snow albedo tuning parameter [s.d. units]**		**ice_shortwave**	
5	rsnw_melt_in	**500.0**	**1500.0**	**2000.0**	**Maximum snow grain radius [μm]**		**ice_shortwave**	
6	ksno	**0.10**	**0.30**	**0.35**	**Thermal conductivity of snow [W / (m °C)]**		**ice_therm_vertical**	
7	mu_rdg	**3.0**	**4.0**	**5.0**	**With ice thickness, gives e-folding scale of ridges [m^(1/2)]**		**ice_mechred**	

Our thanks for extended conversations with the CESM PCWG and especially Dave Bailey, Cecilia Bitz, Bruce Breigleb, Charles Jackson, and Rich Neale.

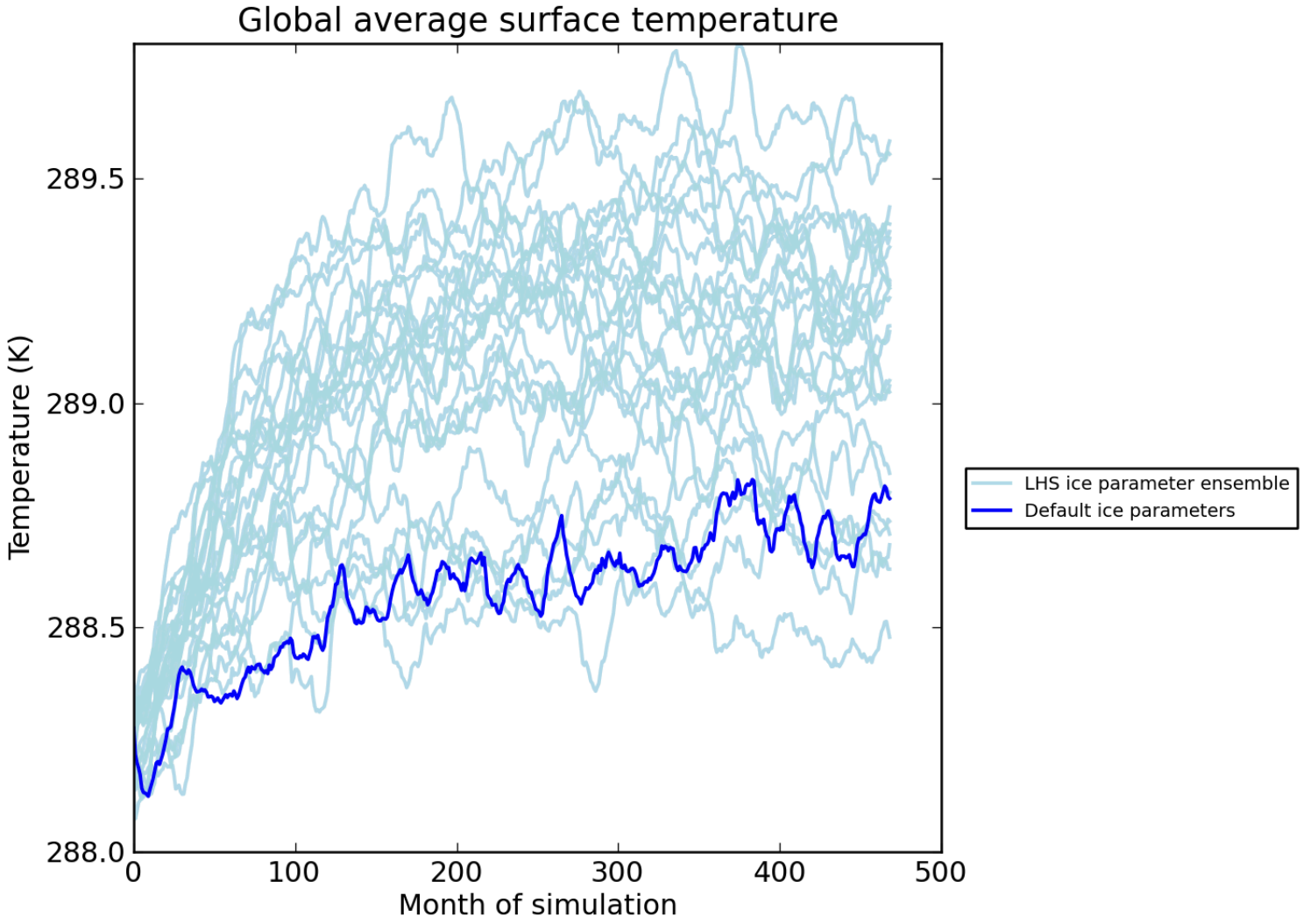
Note: We might be able to test all 2187 possible low / default / high combinations, but that would take us off the main path of our project.

First Test PPE with CAM4+SOM+CICE:

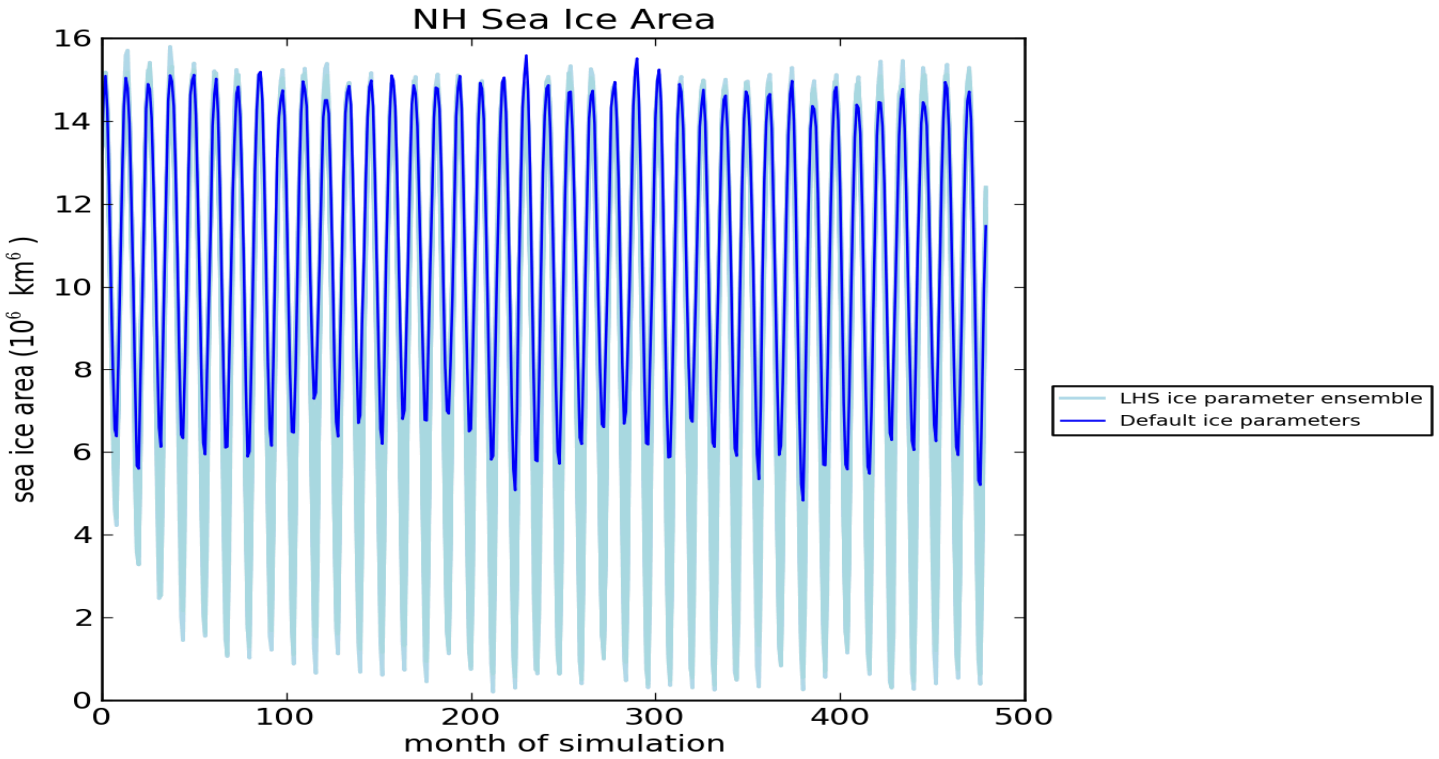


Second Test PPE: Kept CICE input parameters at default values. Same basic result.
Warning: All SOM tests to date use 1°-resolution ocean heat-transport forcing with 1°-resolution CAM4.

Third Test PPE: Kept CAM4 input parameters at default values.



Q: Can polar bears survive all combinations of "reasonable" CICE input-parameter values?



A: Probably not.

How to avoid freezing the model Earth in PPEs? Three possibilities:

1. Pre-filtering: Avoid input-parameter combinations likely to freeze Earth. But how do we know what they are in advance? Stick with combinations already AMIP-tested, or interpolate in 36 dimensions.
2. Kill switch: Check each run early, discard if warning signs appear (e.g. if planetary albedo > 0.32).
3. Traditional "flux correction" for each input-parameter combination: Adjust the prescribed ocean heat flux to whatever value keeps SST within reasonable bounds. But this will violate conservation of energy (globally averaged heat flux out of oceans > 10 W / m2 in most cases). Down-weight unrealistic cases later?

Your advice is welcome!