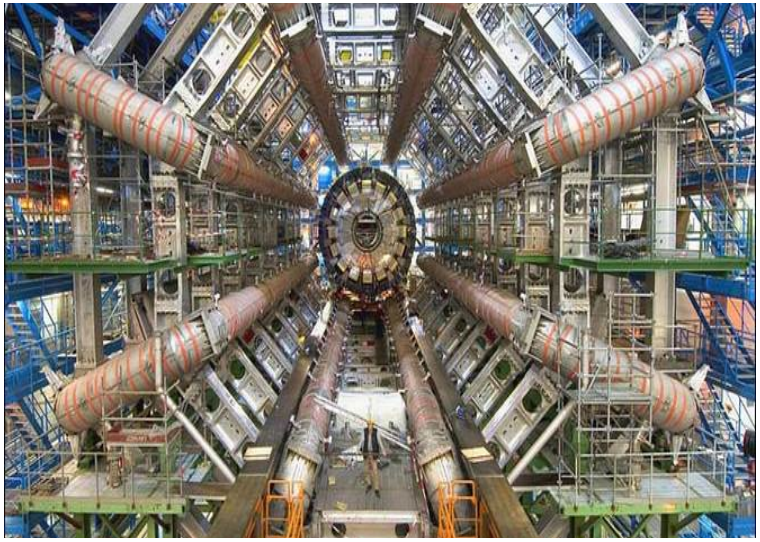
The World of Variability

Victor Zhorin

Variability in Data: detecting anomalies

- summer 1934, Fermi's group in Italy: anomaly detected - neutron induced silver's activity varied noticeably as the experiment was repeated, apparently under the same conditions, with the same procedures
- the Nobel Prize in Physics 1938 was awarded to Enrico Fermi for discovery of nuclear reactions brought about by slow neutrons

- Large Hadron Collider (LHC): 27km long circular tunnel, the total cost of finding the Higgs boson ran **about $13.25 billion**
- The **Worldwide LHC Computing Grid:** one petabyte of data every day



Data sample and hypothesis			15 Dec 2015		17 Mar 2016	
			ATLAS	CMS	ATLAS	CMS
13 TeV	Spin 0	local	3.6 σ	-	3.9 σ	2.9 σ
		global	2.0 σ	-	2.0 σ	< 1 σ
	Spin 2	local	-	2.6 σ	3.6 σ	2.8 σ
		global	-	< 1.2 σ	1.8 σ	< 1 σ
8 TeV + 13 TeV	both	local	-	3.0 σ	Comp-atible	3.4 σ
		global	-	1.7 σ	Comp-atible	1.6 σ

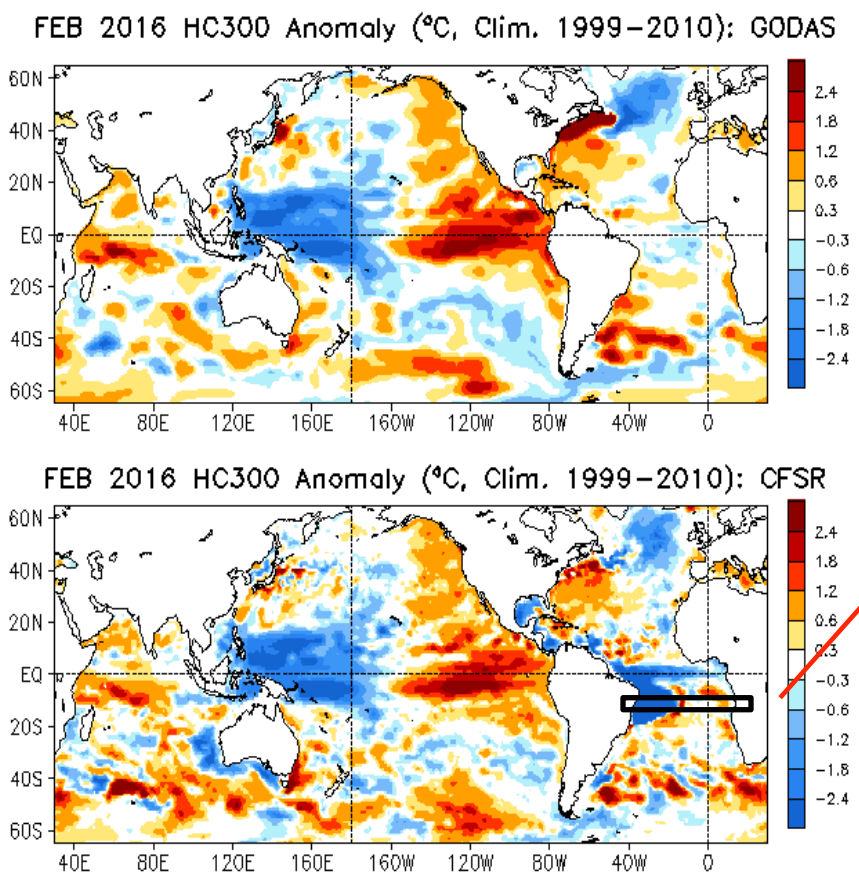
Operational US Weather Model Cold Bias Problem

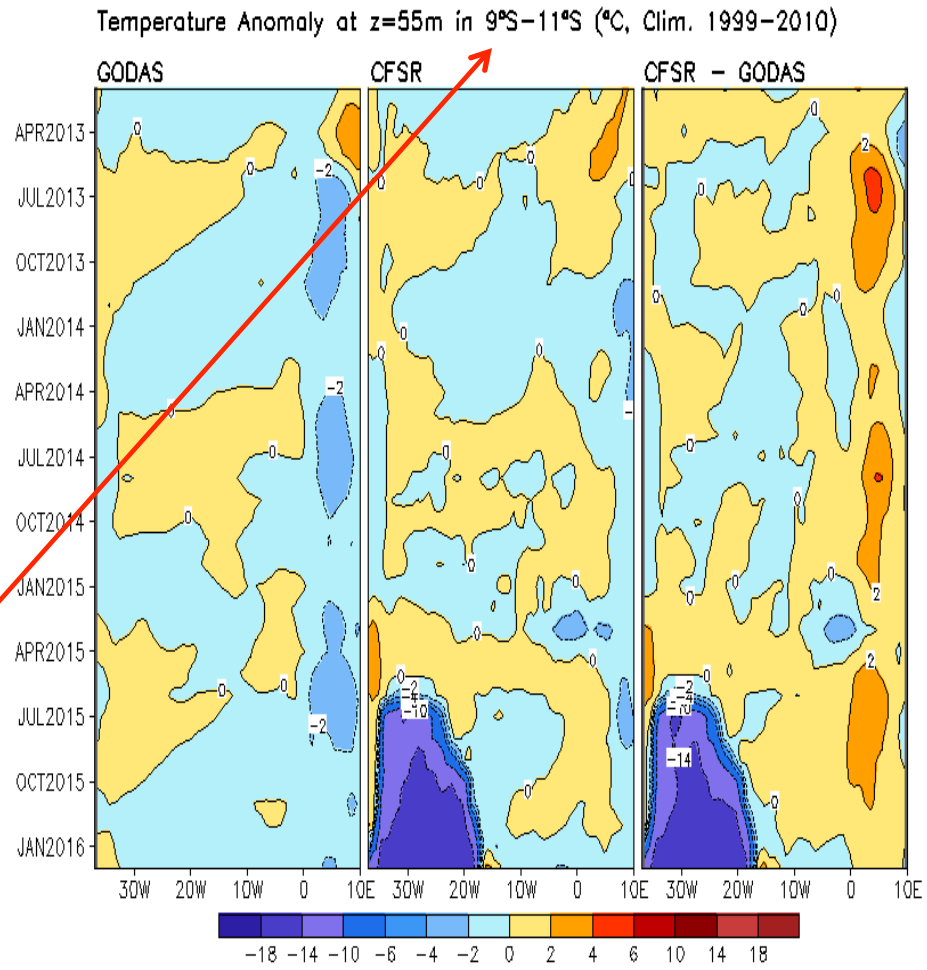
- A large cold bias emerged in the ocean initial conditions along the equator in the spring of 2015, and grew to include the South Atlantic in the summer of 2015. These cold biases had translated into cold biases in the same regions in CFSv2 forecasts.

- The presence of these large cold biases was noted by several external and internal stakeholders. The ENSO forecasts from the CFSv2 from December 2015 showed unusual behavior, in that the El-Nino event did not transition to neutral, but rather experienced a double-dip El-Nino, which is unprecedented in the modern era.

from NOAA briefing

Recent Cold Biases in Tropical South Atlantic

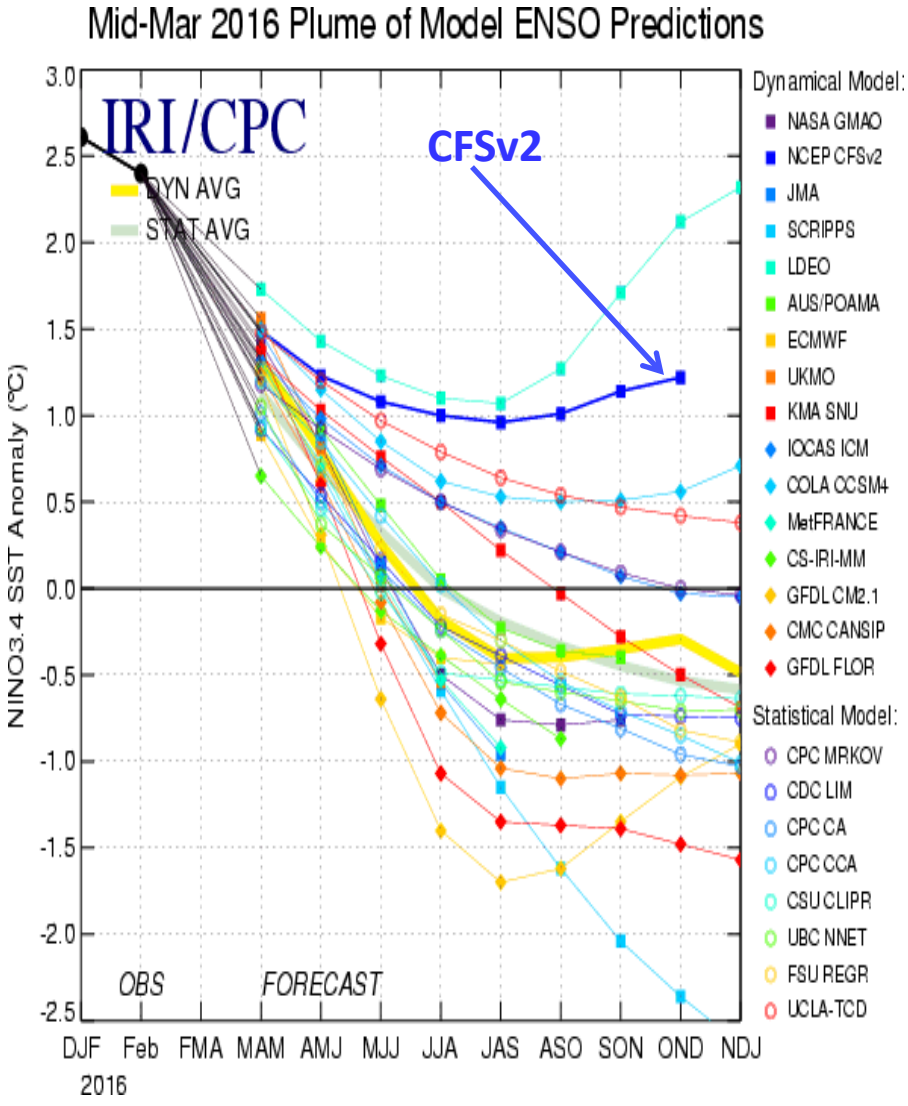




- **A cold bias emerged around 10S in the South Atlantic around Jul 2015 and enhanced quickly with time.**
- **It reached -18 degree at 55m depth since Oct 2015.**

from NOAA briefing

Impact on ENSO Evolution



Background Science Material

- The cold spots in the CFSv2 appear in the equatorial zone both north and south of the equator. The increased resolution in the equatorial zone (0.25^{o}) means the model is "eddy permitting" but not "eddy resolving".

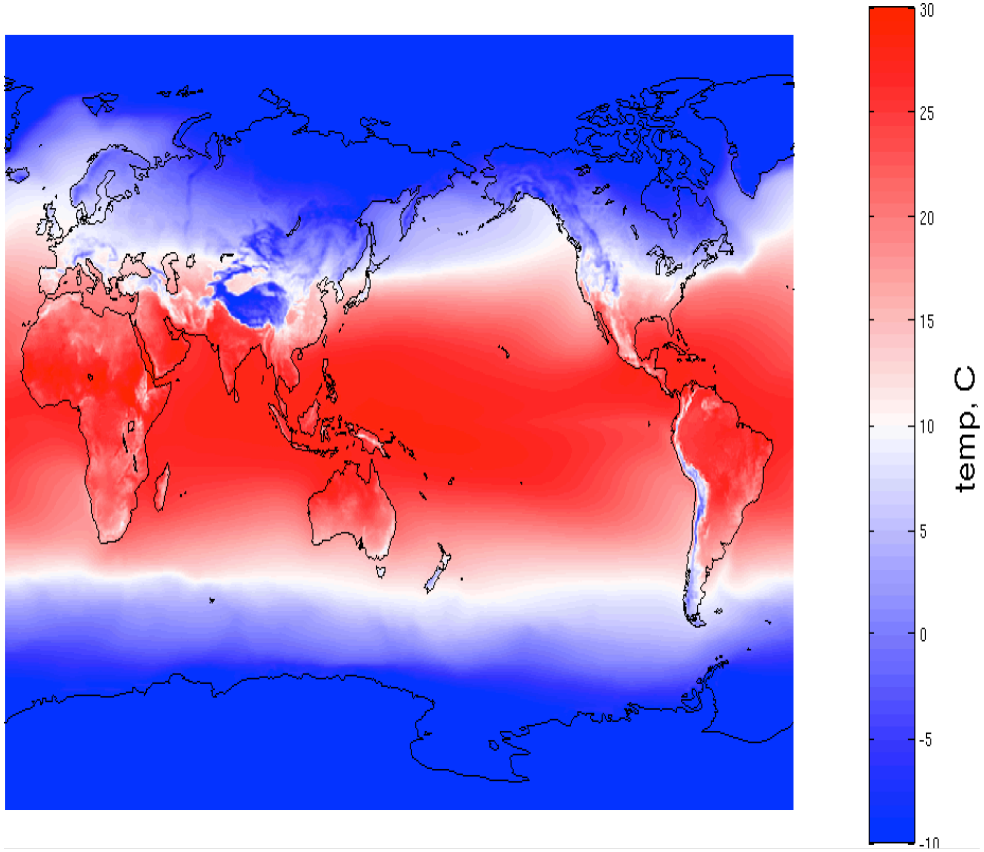
- **That part of the western Atlantic is particularly energetic.** Therefore, the model produces a lot of eddies there that have no exact correspondence in the real world as observed by the profile data. As a consequence**, the assimilation in that area produces noise rather than a correction and grows both spatially and temporally**.

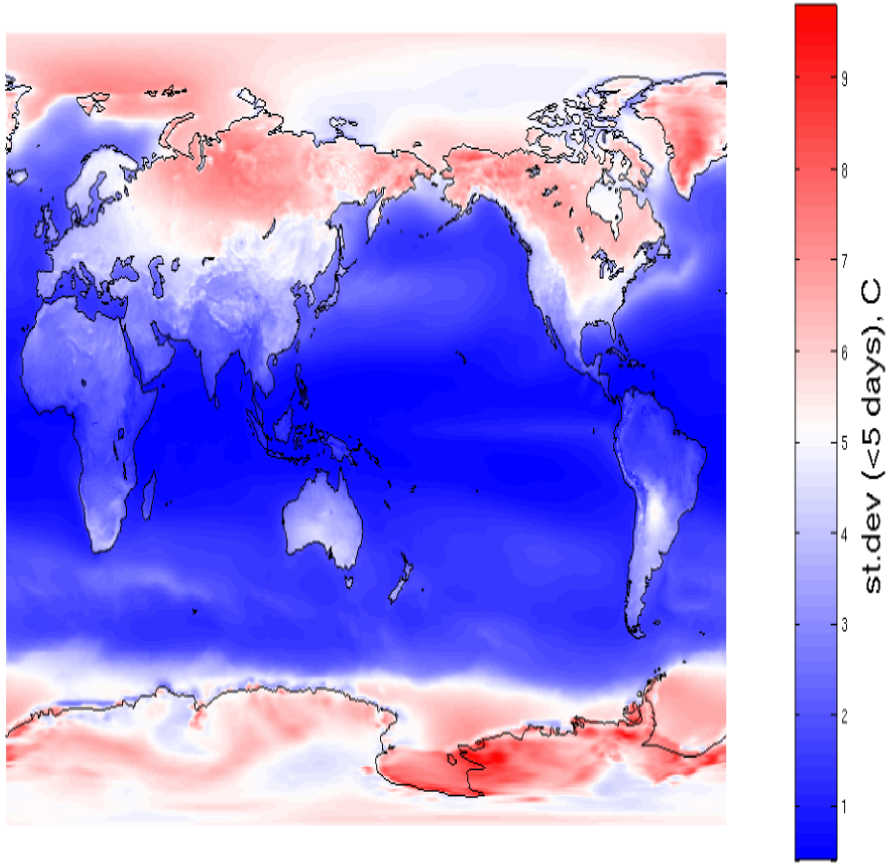
- An emergency fix is to re-initialize the CFSv2 by replacing the ocean initial states with those from an off-line GODAS, in which a weak relaxation to climatology (the NODC WOD09) has been introduced, to control the noise.

- Experiments have to be conducted while changing the frequency of the assimilation cycle **and estimates of background and observation errors**.

from NOAA briefing

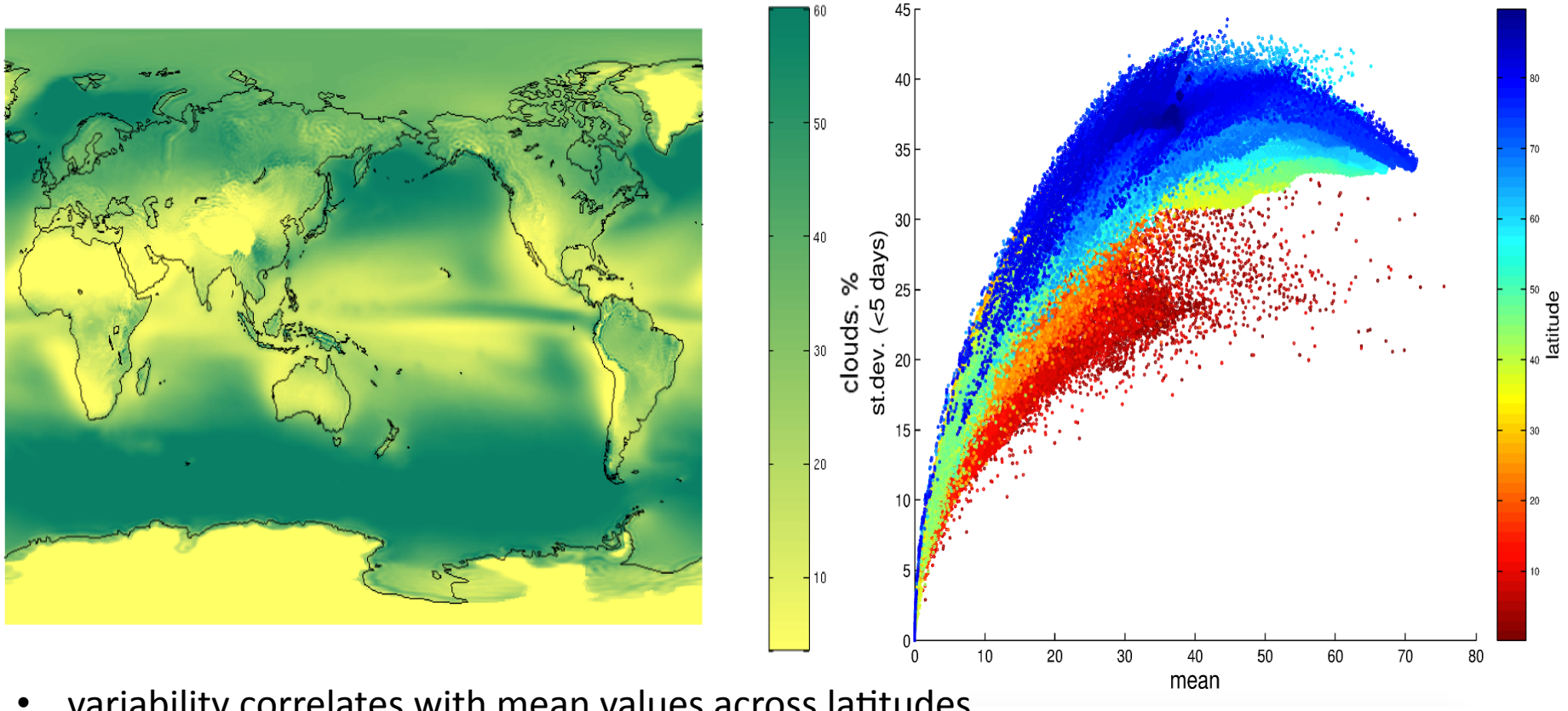
Natural Variability: Stochastic vs. Deterministic Temperature





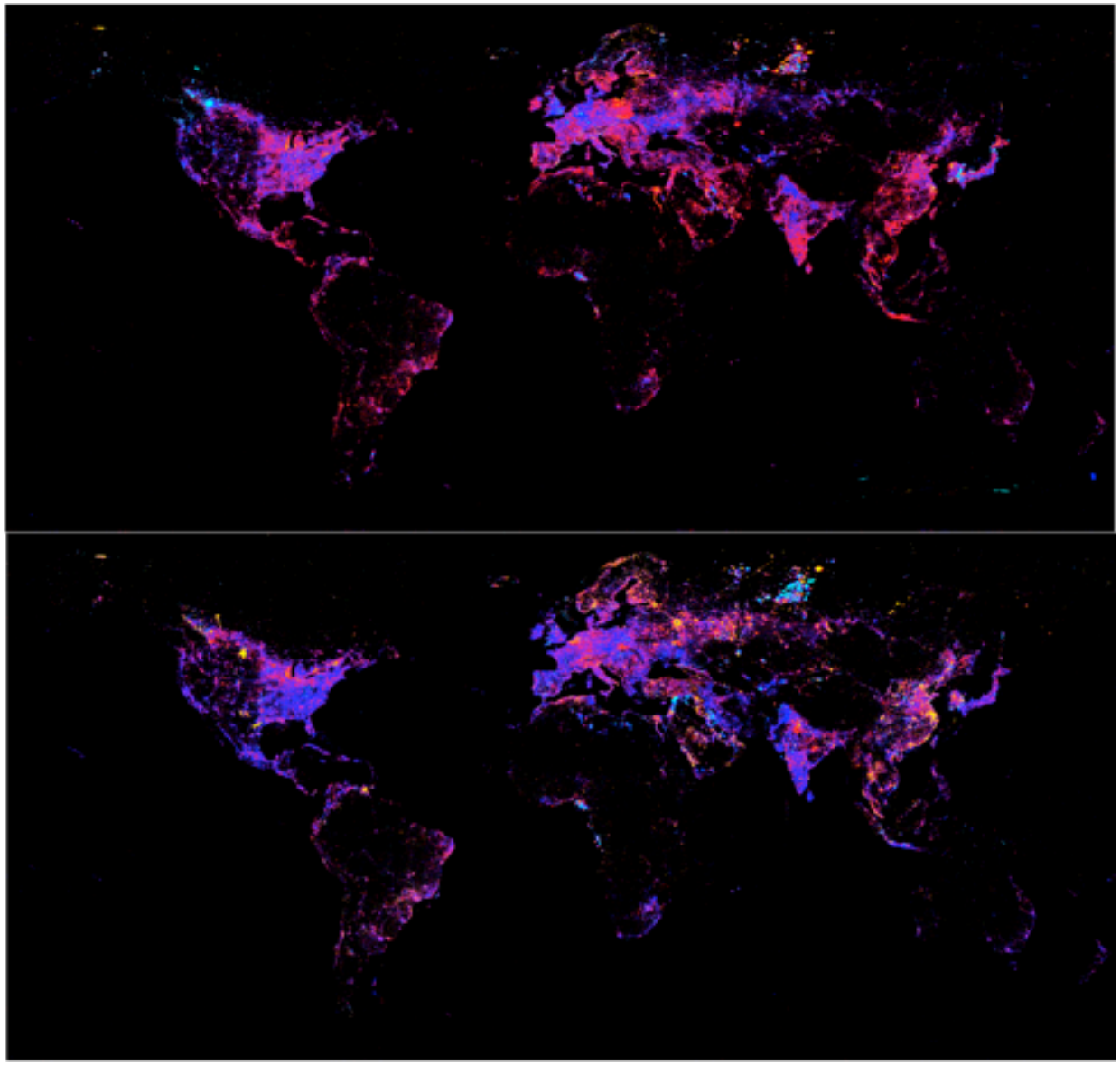
- mid latitudes: low mean, high natural variability
- tropics: high mean, low natural variability
- tropical land similar to tropical ocean

Natural Variability: Stochastic vs. Deterministic Low Clouds



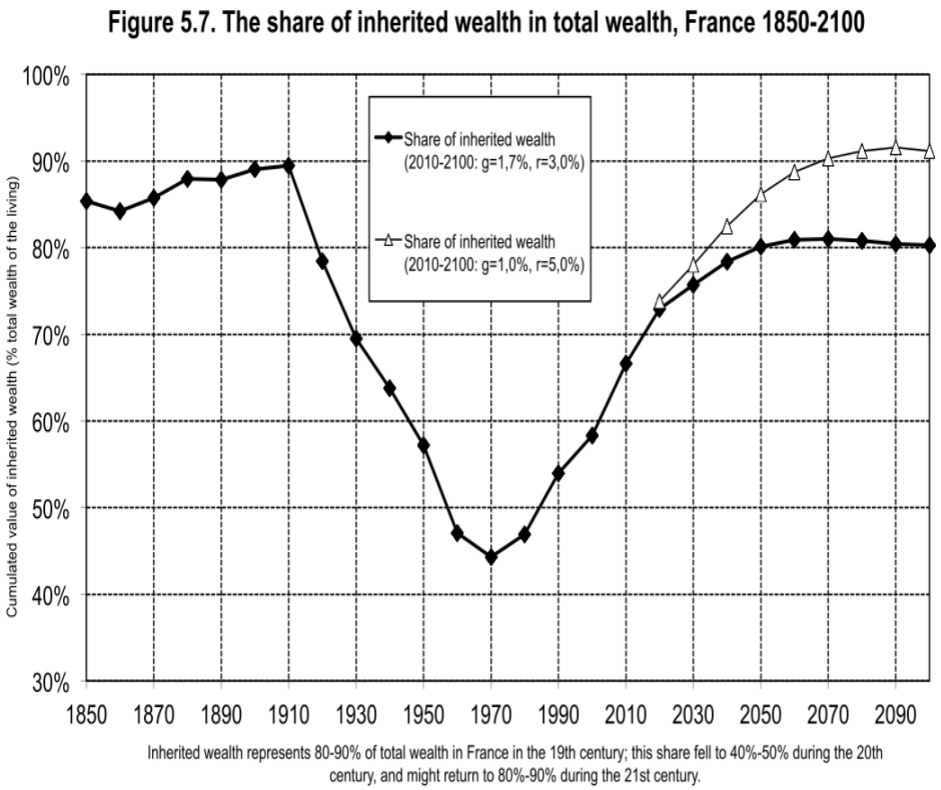
- variability correlates with mean values across latitudes
- heterogeneity across latitudes

Socio-Economic Variability: Night Lights
Duede-Zhorin, 2016

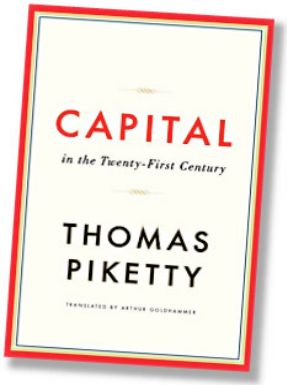


- night lights as a proxy for economic growth
- distributional impact of economic development
- propagation of economic shocks (The Great Recession effects)
- blue areas – relative decay, red areas – relative growth
- Top: 2006-1993 period, bottom: 2013-2007 period
- tight oil (Permian, Eagle Ford, Bakken)
- transfer of wealth in EU
- decaying oil/gas fields
- rapid growth in coastal China
- high heterogeneity in growth both across countries and within the countries

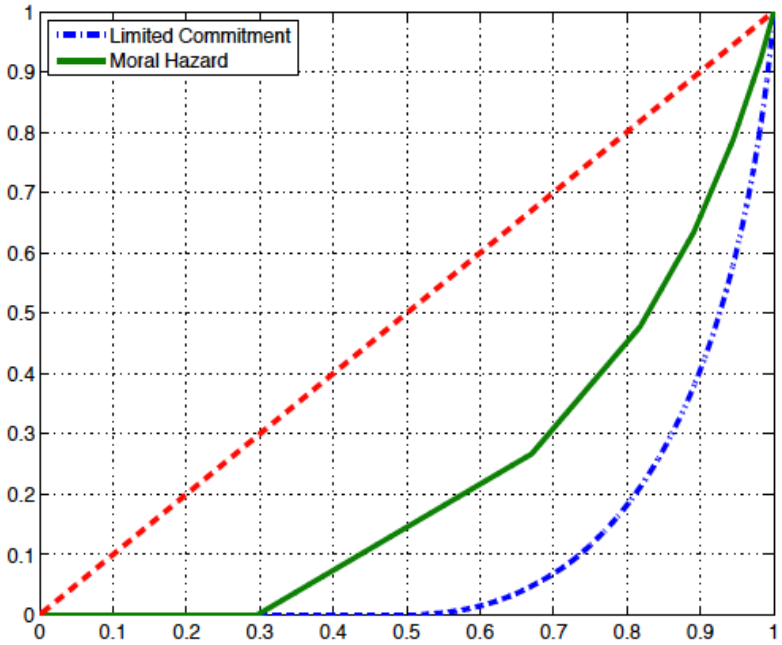
The Fundamental Force for Divergence: r > g?



Piketty and Zucman (2014)



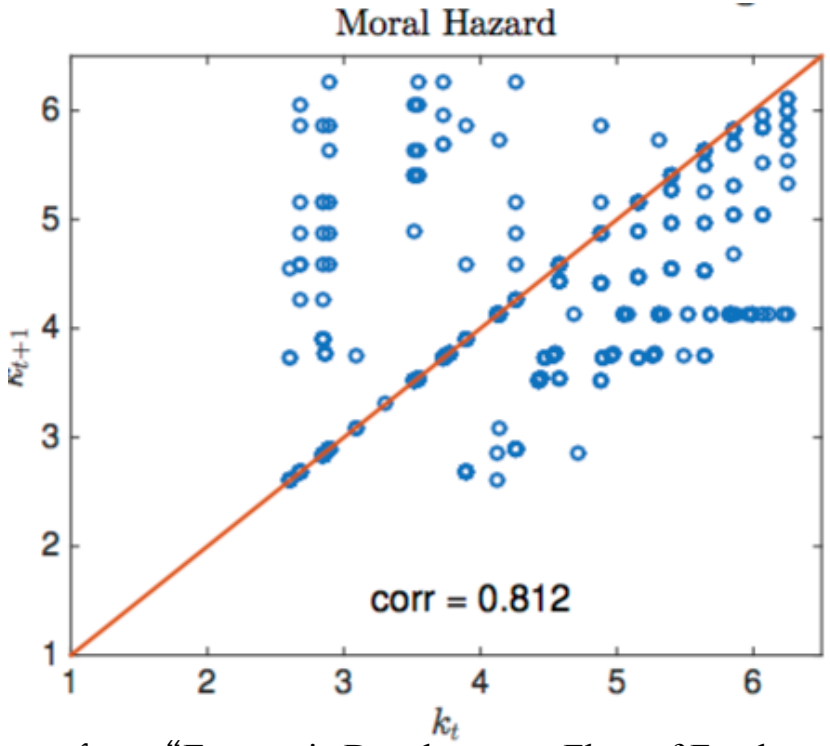
Wealth Lorenz Curves

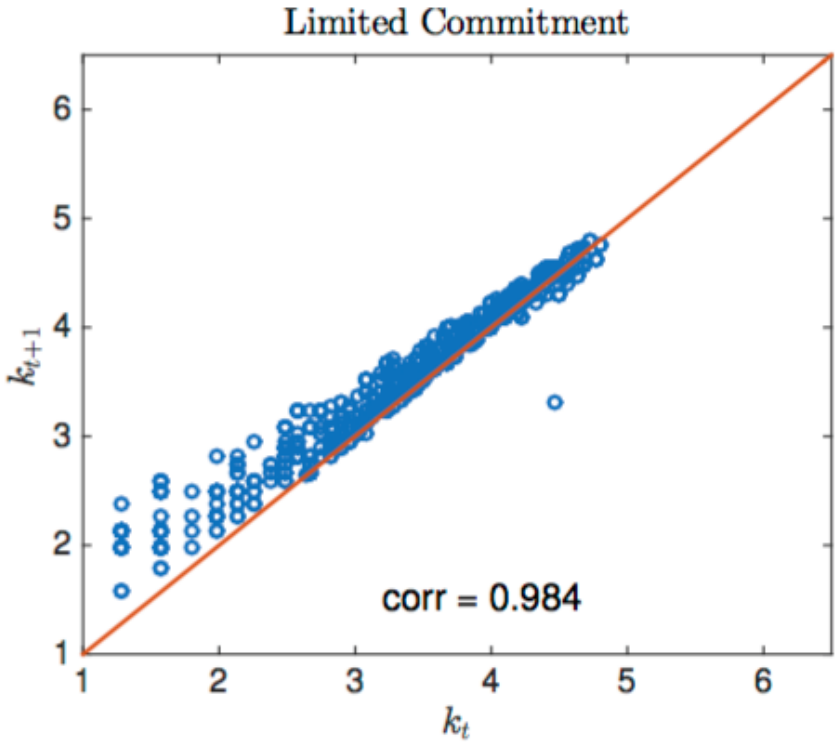


from "Economic Development, Flow of Funds and the Equilibrium Interaction of Financial Frictions"
B. Moll, R. Townsend, and V. Zhorin, 2016

Cross-Regional Variation in Financial Frictions

Heterogeneous Agents in Stochastic Environment



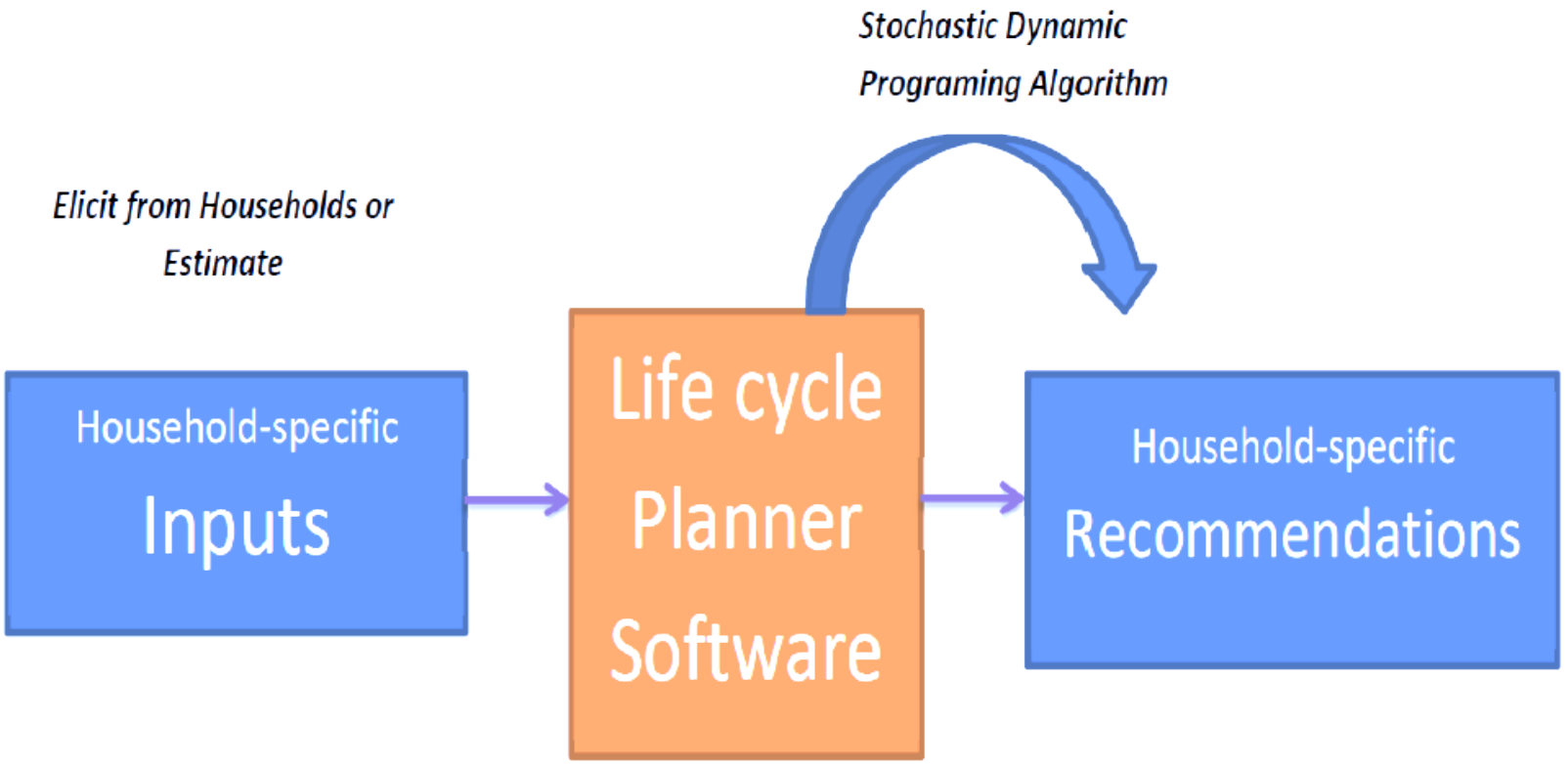


from "Economic Development, Flow of Funds and the Equilibrium Interaction of Financial Frictions "
B. Moll, R. Townsend, and V. Zhorin, 2016

- firm size distribution in the urban (moral hazard) area has more mass in the right tail, as is true in the data, in contrast with the rural (limited commitment) area
- there is more variability in wealth growth rates in rural areas than in urban ones
- borrowing is increasing in wealth for the limited commitment regimes
- high degree of persistence of capital in the limited commitment

Wealth Management Software: smoothing consumption variability

(with Stefanie Stantcheva and Rob Townsend)



FINTECH: Lifecycle Consumption Variability Smoothing