Land-atmosphere coupling in global fully coupled storm-resolving simulation

Junhong Lee and Cathy Hohenegger

Max Planck Institute for Meteorology, Germany
junhong.lee@mpimet.mpg.de

Motivation

- Different land-atmosphere coupling signs and strengths have been reported by past studies with global coarse resolution simulation and past studies with regional high resolution simulation

- This is because,
  · global coarse resolution cannot consider 1) detail topography, 2) land surface heterogeneity (e.g. landuse), and cannot resolve 3) small-scale circulation (e.g. vegetation breeze)

  · regional high resolution cannot consider 1) larger scale circulation and 2) impact of the ocean (e.g. moisture fluxes)

- What does land-atmosphere coupling look like with global fully coupled storm-resolving simulation?

- How is it different from coarser resolution simulation in terms of coupling pattern and strength?

Method

Data:

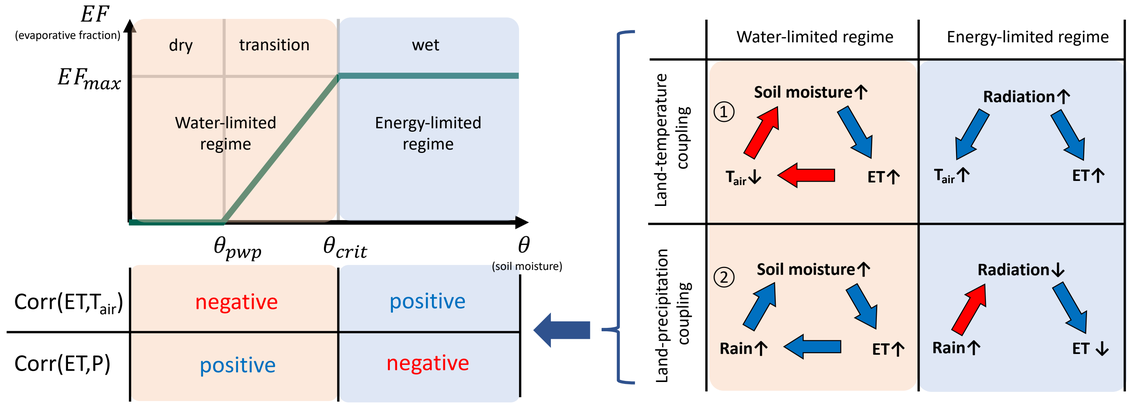
Name	Resolution	Period	Reference
ICON5	5 km	JJA, 2020	NextGEMS simulation
ICON160	160 km	JJA, 60 years	CMIP6 low-res ICON
FLUXNET 2015	-	JJA, 1991-2014	Pastorello et al. 2020

NextGEMS project

Project to develop two next generation (storm-resolving) Earth-system Models. These models will allow us to understand and reliably quantify how the climate will change on a global and regional scale.

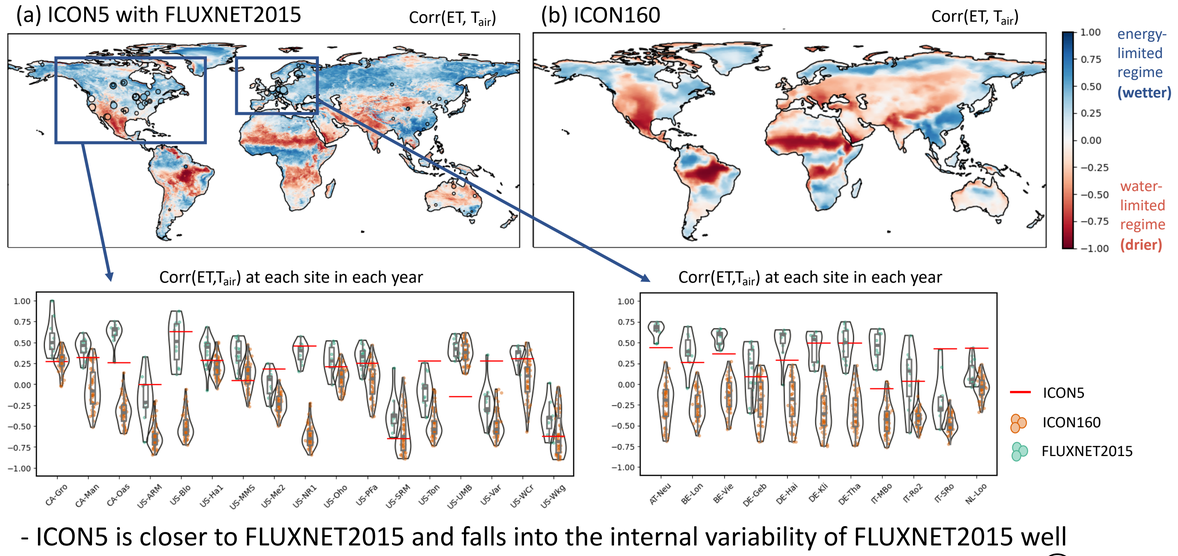
https://nextgems-h2020.eu/

Coupling metrics: correlation coefficient:



Land-temperature coupling

Correlation coefficient:



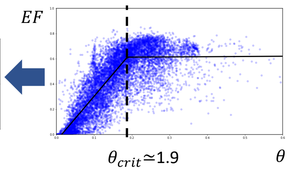
- ICON5 is closer to FLUXNET2015 and falls into the internal variability of FLUXNET2015 well
- ICON160 shows stronger negative Corr(ET, T_{air}) → stronger coupling in low resolution in ① water-limited regime

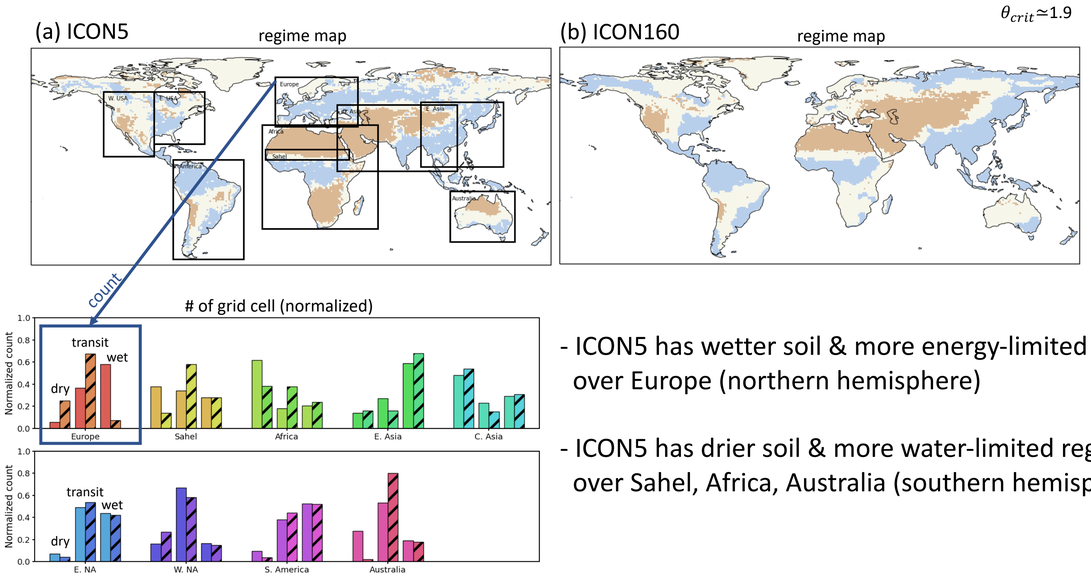
- Correlation coefficient shows the opposite sign between ICON5 and ICON160 over Europe
  → Hydrological regime can be different between ICON5 and ICON160

Hydrological regime:

- Determine regime:

regime	dry	transition	wet
condition	$\theta < \theta_{pwp}$	$\theta_{pwp} < \theta < \theta_{crit}$	$\theta_{crit} < \theta$



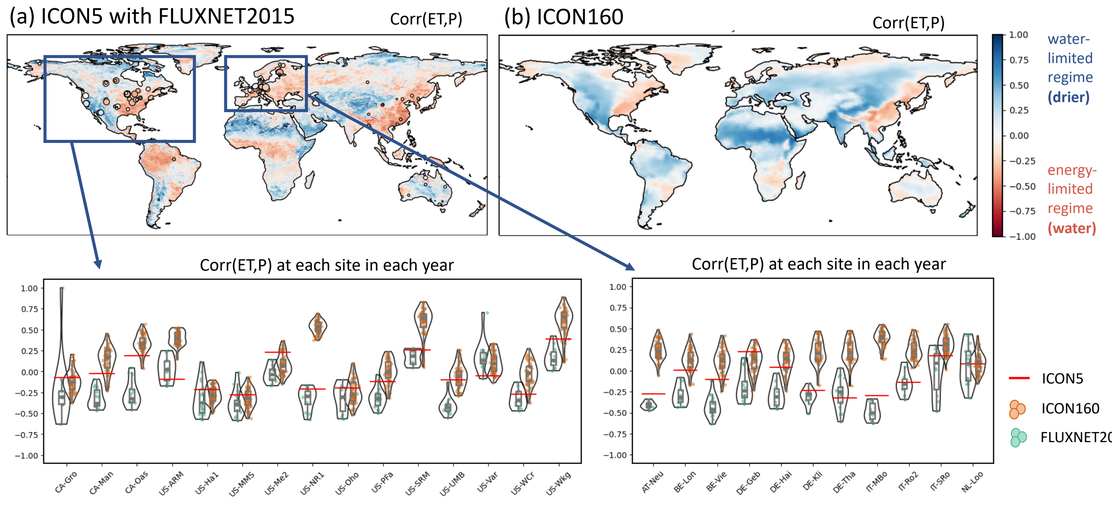


- ICON5 has wetter soil & more energy-limited regime over Europe (northern hemisphere)

- ICON5 has drier soil & more water-limited regime over Sahel, Africa, Australia (southern hemisphere)

Land-precipitation coupling

Correlation coefficient:



Contribution to coupling (Sahel):

	ΔP/ΔET	ΔET/ΔSM
ICON5	16.66	0.0163
ICON160	39.32	0.1641
Ratio (ICON5/ICON160)	0.424	0.099

- Again, ICON5 is closer to FLUXNET2015

- Corr(ET,P) shows the opposite sign between ICON5 and ICON160 over Europe

- ICON160 shows stronger positive Corr(ET, P) in ① water-limited regime
  → larger ΔP/ΔET and ΔET/ΔSM indicates stronger coupling and ET-SM link is dominating factor

Summary & conclusion

Land-atmosphere coupling in storm-resolving simulation and coarser resolution simulation:

1. Two resolution simulations show opposite coupling signs over Europe
2. Storm-resolving simulation is close to the observation
3. Storm-resolving simulation shows weaker coupling strength in water-limited regime