ATM 265, Spring 2019

Lecture 15

Future Earth System Modeling

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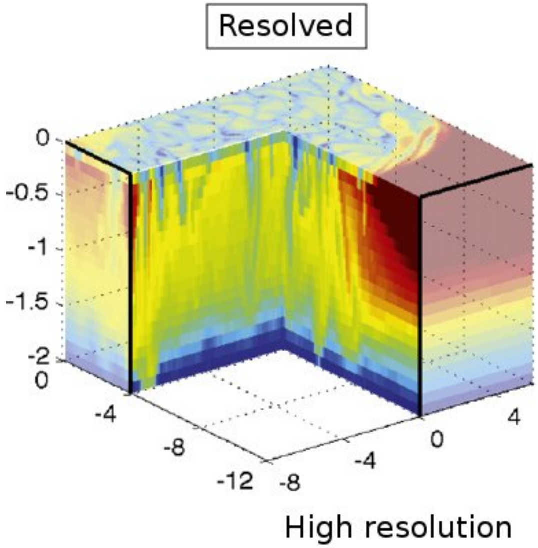
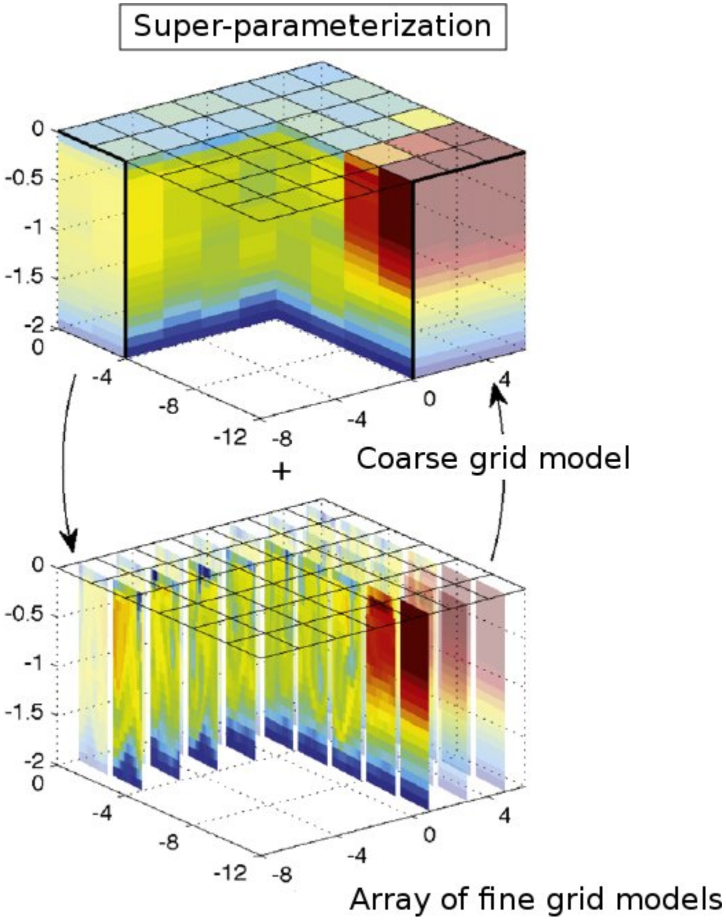
Superparameterizations

Rasp, S., Pritchard, M.S. and Gentine, P., 2018. Deep learning to represent subgrid processes in climate models. *Proceedings of the National Academy of Sciences*, *115*(39), pp.9684-9689.





High resolution is already being sought via alternative avenues. Clouds, which are sub-gird-scale at current resolutions, can be resolved on finer scale sub-element grids.

Significant ongoing work using superparameterizations by Michael Pritchard (UCI), Gabe Kooperman (UGA), and Walter Hannah (LLNL).

Physgrid

When using the spectral element dynamical core, the inhomogeneity of the grid can trigger analogous inhomogeneity in the dynamics fields (particularly governing divergence and vorticity). This can in turn lead to grid imprinting within each spectral element on the vertical velocity.

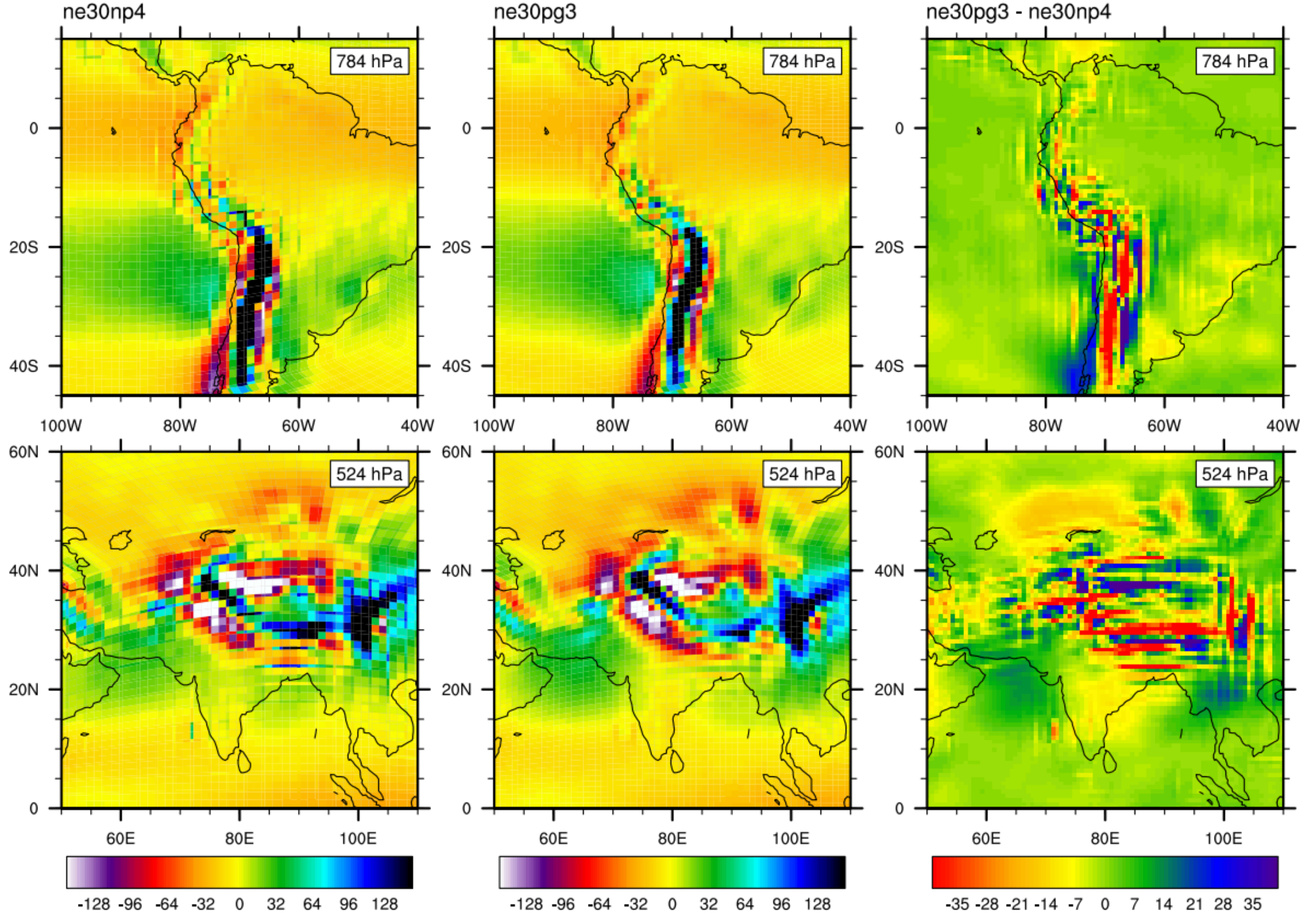


Figure: Vertical pressure velocity in a region of rough topography.

Physgrid

Herrington, A.R., P.H. Lauritzen, M.A. Taylor, S. Goldhaber, B.E. Eaton, K.A. Reed, and P.A. Ullrich (2018) "**Physics-dynamics coupling with element-based high-order Galerkin methods: Quasi equal-area physics grid**" *Mon. Weather Rev.*, 147 (1), pp. 69-84, doi: 10.1175/MWR-D-18-0136.1.

- Decoupling of the physics and dynamics grid enables more uniform application of physics tendencies without impacting the global climate.

- Physics can use a uniformly spaced grid that is constructed within each spectral element.

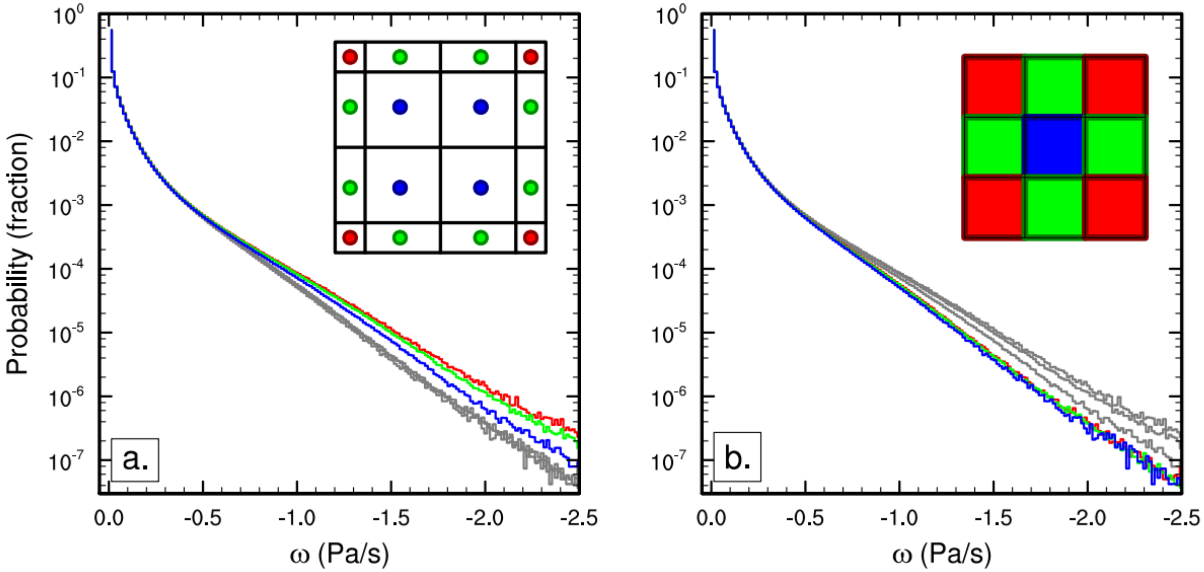


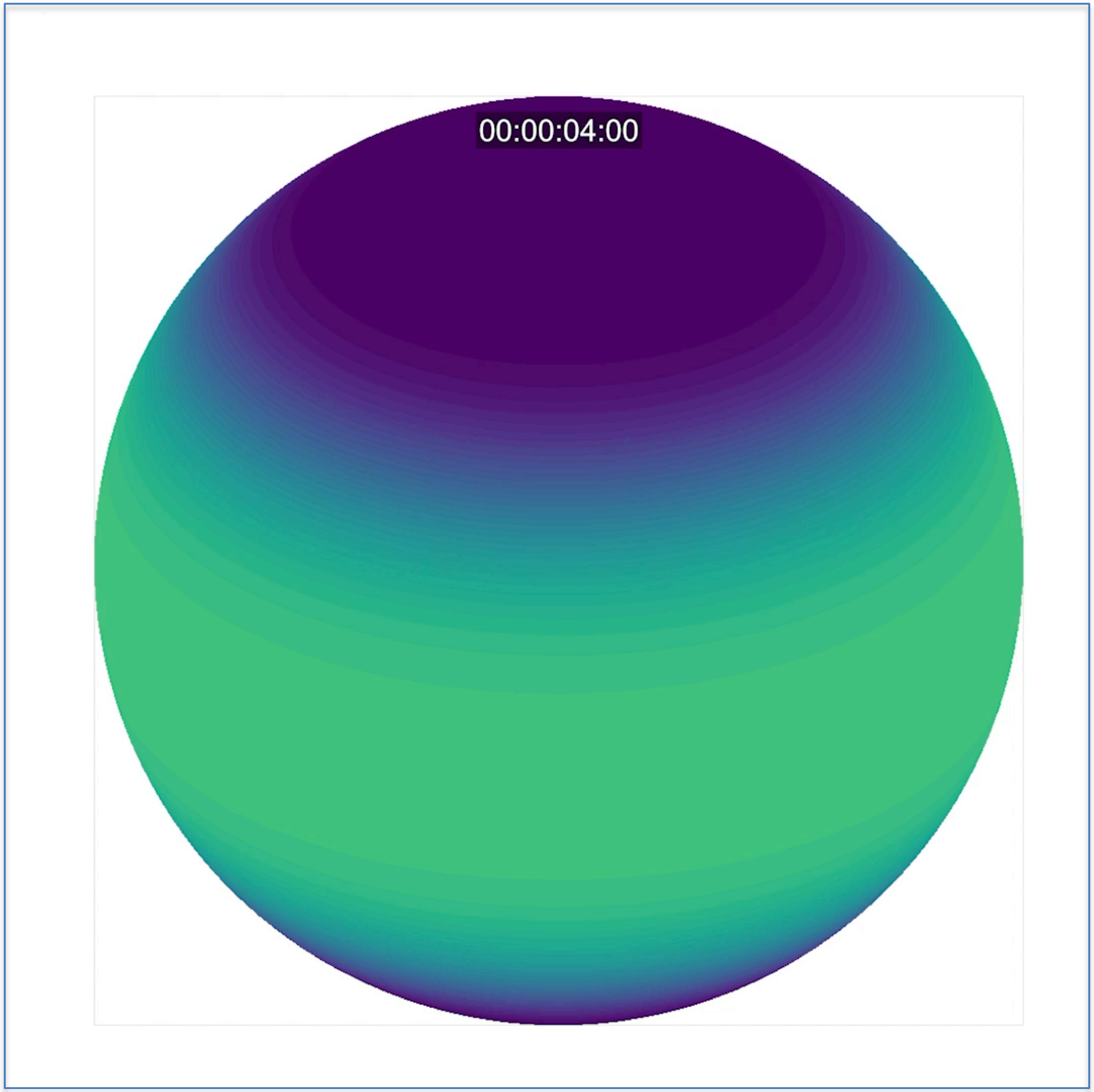
Figure: Frequency distribution of vertical pressure velocities depending on location within Spectral Element grid cell.

Non-Hydrostatic Dynamics

Idealized baroclinic instability HOMME-NH standalone run at ne1024.

ne30	110km (1 deg)
ne60	55km
ne120	28km
ne240	14km
ne480	7km
ne960	3.5km
ne1024	3.2km

Movie shows the specific humidity field at 500hPa.

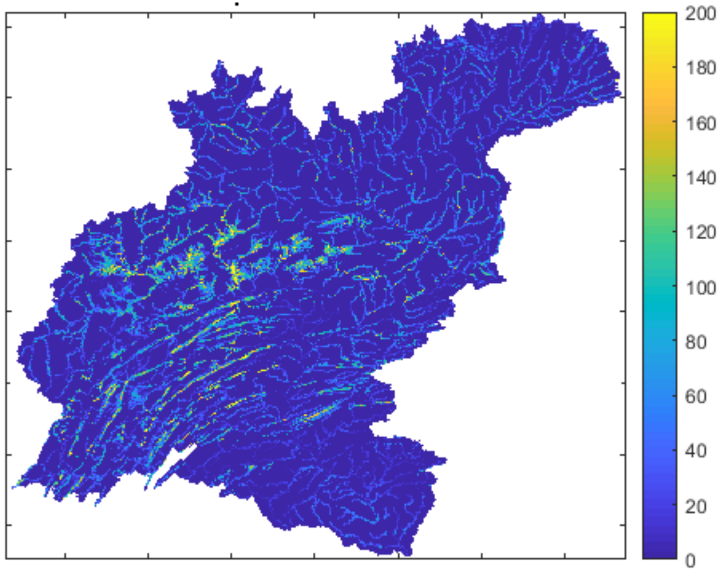


Integrated Hydrologic Modeling

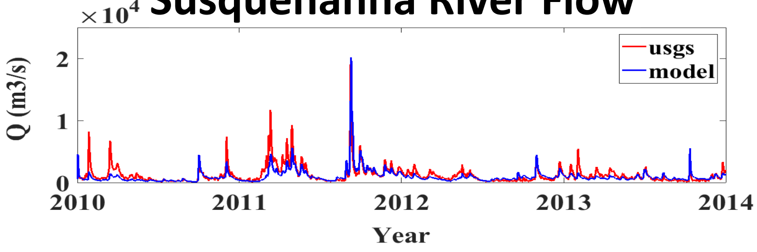
Increasing focus on modeling the complete water cycle, which requires accounting for overland and subsurface flow.

Hydrologic models are highly dependent on soil and land-surface data, plus are subject to human intervention (i.e. water diversions, reservoir management).

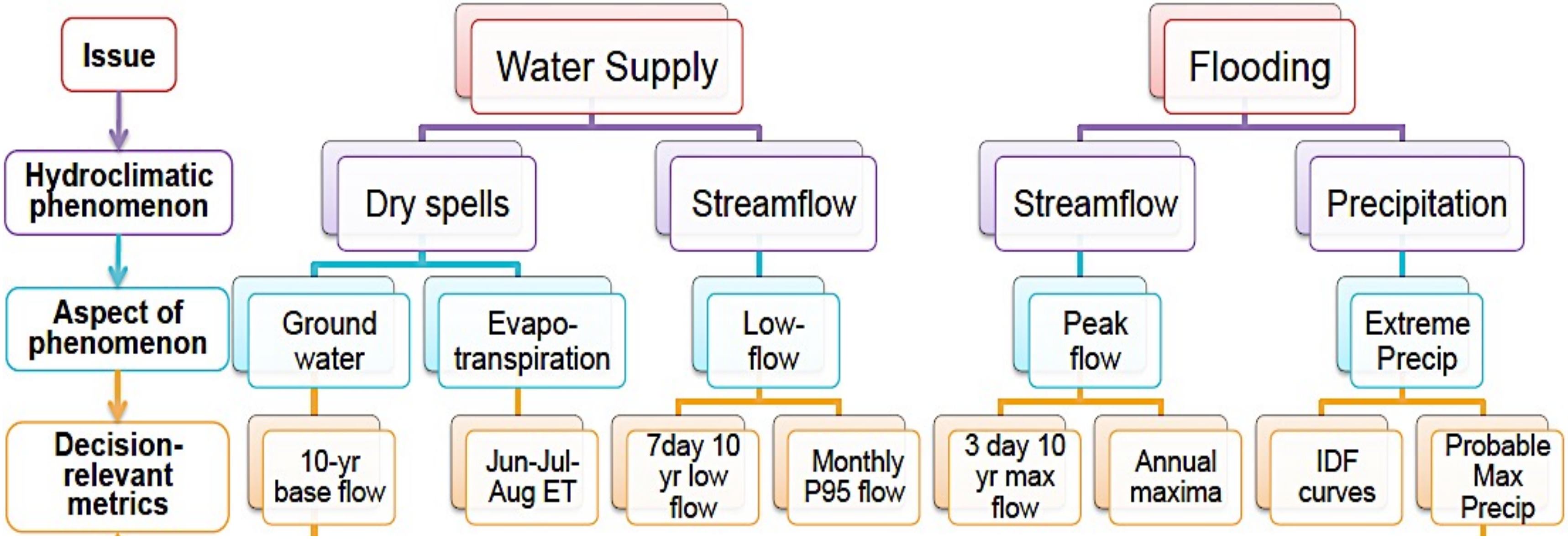
Susquehanna River Basin – depth to water table



Susquehanna River Flow



Model Evaluation



- Focus on new metric development to understand how models are capturing particular phenomena or processes.
- Use-inspired metric development puts the focus on how climate models and datasets are being used in practice.

Bias Propagation

A decomposition of model errors in SWE into upstream drivers (Yun Xu and Andrew Jones).

Evaluation Simulations*	Total error ε	From Accum. ε_A	From Precip. ε_P	From Mean Precip. $\varepsilon_{\bar{P}}$	From Precip. Distrib. $\varepsilon_{P'}$	From Temp. ε_T	From Topo. $\varepsilon_{\tilde{T}}$	From Residual Temp. $\varepsilon_{T''}$	From Thresh. Temp. ε_{Th}	From Ablation ε_M
CRCM5 – 44	-69%	-44%	-31%	-23%	-10%	-16%	-31%	13%	0%	-41%
CRCM5 – 22	-47%	-16%	-24%	-8%	-17%	6%	-12%	17%	0%	-33%
CRCM5 – 11	-38%	-9%	-21%	-1%	-20%	9%	-5%	13%	0%	-30%
CanRCM4 – 44	-87%	-55%	-50%	-42%	-13%	-6%	-31%	25%	0%	-64%
CanRCM4 - 22	-65%	-29%	-43%	-30%	-18%	25%	-12%	35%	0%	-46%
RegCM4 - 44	-56%	72%	-20%	-1%	-19%	13%	-33%	40%	55%	-67%
RegCM4 - 22	33%	153%	7%	34%	-20%	39%	-13%	46%	55%	-43%
WRF - 44	-77%	-20%	-18%	-16%	-2%	-5%	-17%	13%	0%	-64%
WRF - 22	-55%	12%	-5%	-2%	-3%	16%	-6%	22%	0%	-54%

Big Error in Ablation! Need radiation outputs from models to further partition...

SWE Error is BIG

cold bias after elevation correction

Even if correct for mean precip, spatial distribution produces underestimation in SWE (too much at mid-elevation and not enough at high)

Unresolved topography by model resolution leads to warm bias.