Hydrological extremes and large-scale meteorological patterns associated with coastal cyclones over the eastern United States

Colin Zarzycki … and others!

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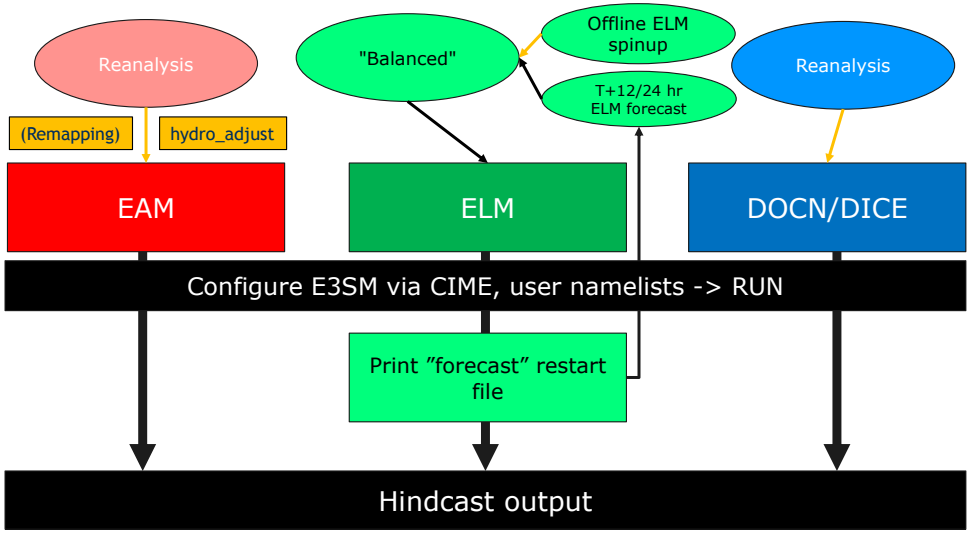
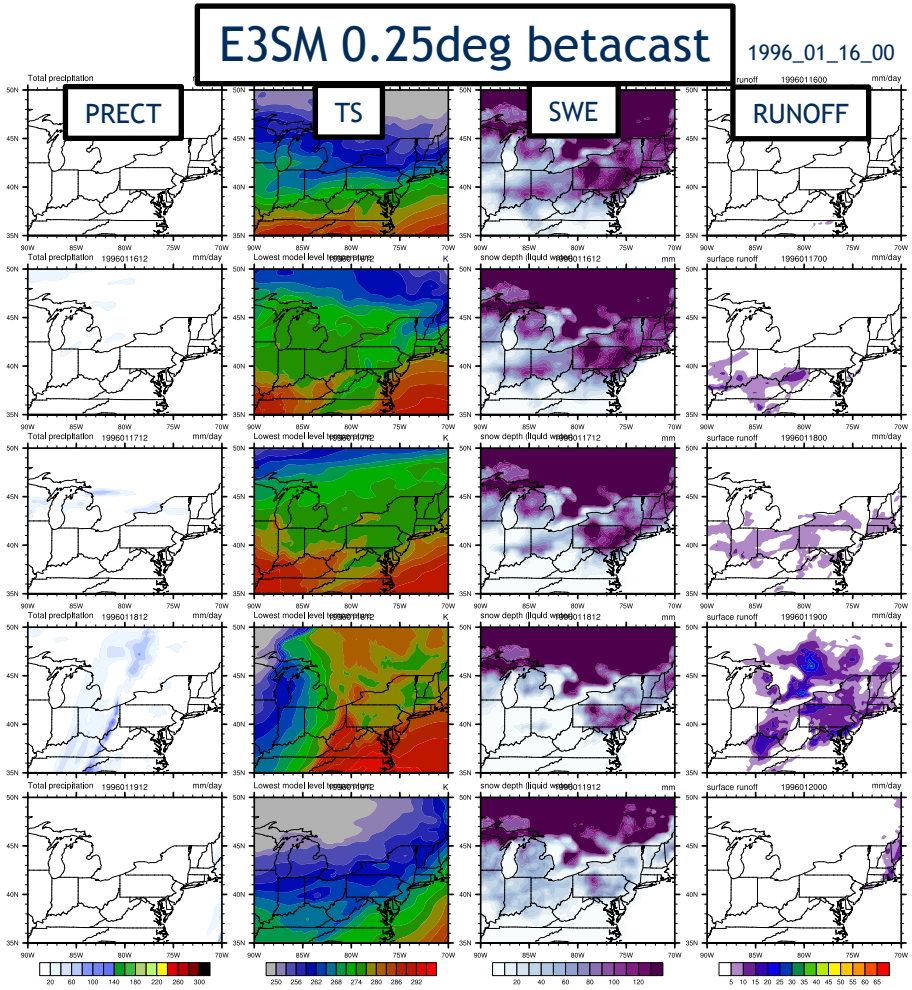
U.S. Department of Energy | Office of Science
HYPERFACETS
A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

- ESM initialization code (betacast) ported to E3SM!
- **Storylines**: Evaluation of historical coastal extremes under plausible scenarios

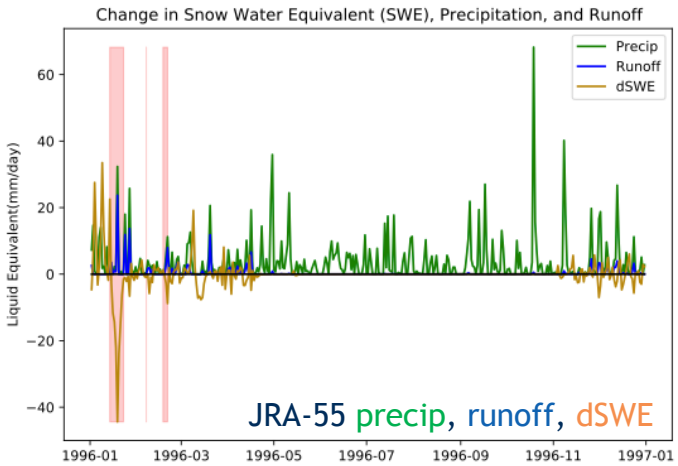


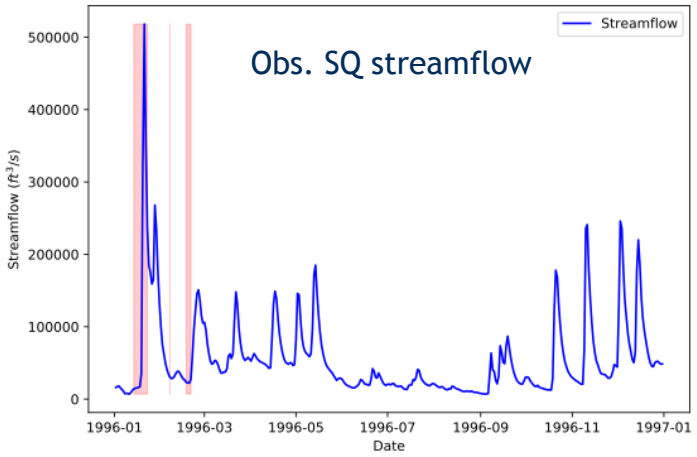


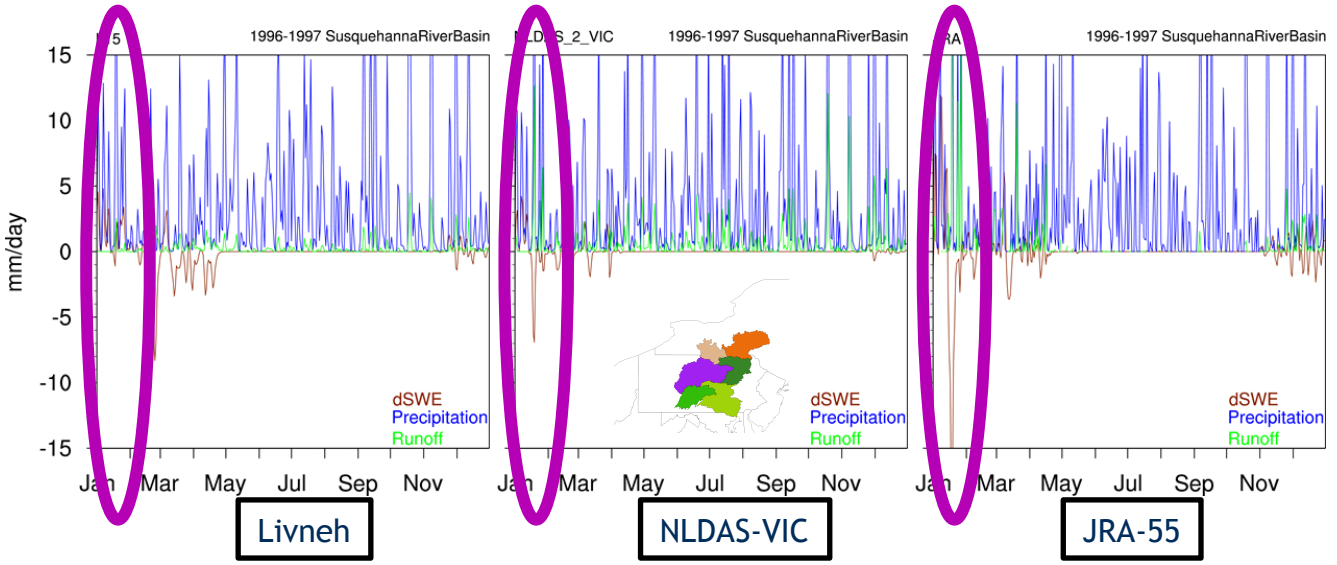
https://github.com/zarzycki/betacast

Basin-scale rain-on-snow metrics

- Evaluate gridded data at the basin-scale level to detect rain-on-ephemeral-snow streamflow spikes
- Highlights large hydro dataset discrepancies







… with: Alan Rhoades (LBNL), Ben Ascher (PSU), Rachel McCrary (NCAR)

Tying large-scale patterns to cyclonic storms

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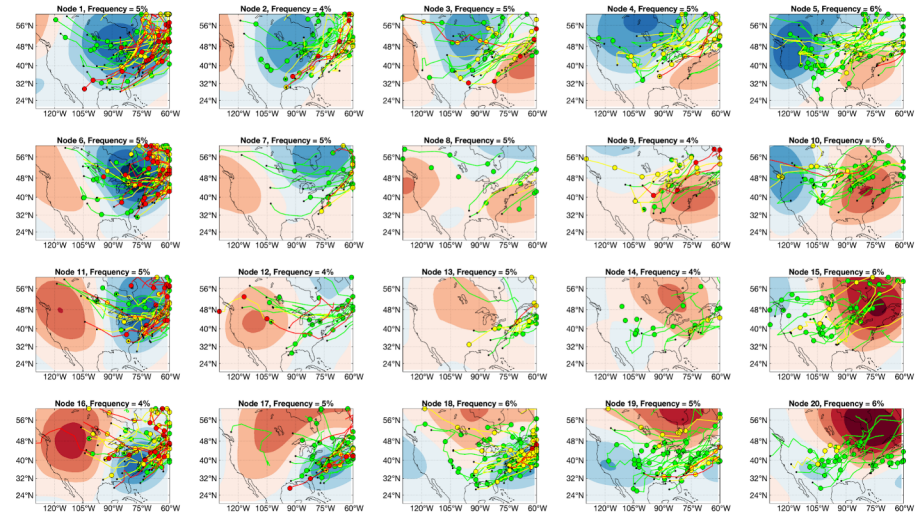
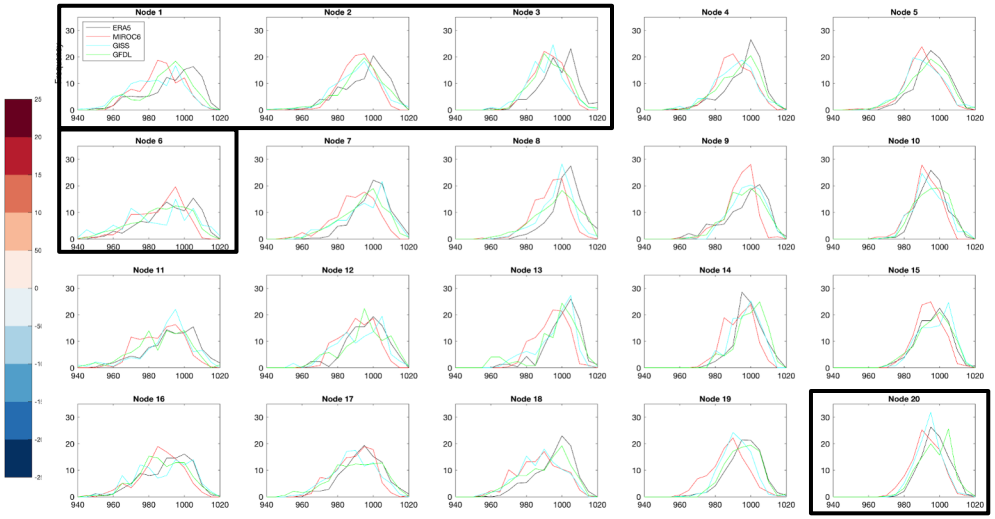
4 x 5 MASTER SOM - 500hPa Geopotential Height
1980 - 2019 : ERA5, JRA, MERRA2, CFSR -- 1980 - 2015 : CR20



ETC intensity distribution by node for ERA5 + selected CMIP6 models



- Self-organizing maps (SOMs) to classify meteo. patterns associated with EUS coastal storms
  - Cyclones tracked w/ TempestExtremes
  - Z500 SOMs trained w/ reanalysis → evaluate biases in CMIP6
- Models overrepresent "extreme" (amplified) wave patterns

Node frequency bias (Z500) for ERA5 + selected CMIP6 models + means

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	FE	SE
ERA5	-0.08	-0.05	0.52	0.14	1.15	-0.1	-0.38	-0.29	-0.66	-0.14	0.43	-0.27	-0.42	-0.19	0.04	0.4	0.03	-0.16	0.11	-0.1	0.283	0.03
MRI-ESM2-0	7.9	-1.87	8.57	1.34	-3.76	2.67	-0.35	-1.03	0.41	-1.65	-3.74	-1.43	-1.91	0.39	-1.64	-0.57	0.37	-3.08	-2.51	2.19	2.369	0.71
NOAA GFDL	-1.56	-0.95	0.63	0.87	0.91	0.92	0.03	-1.54	-0.76	-0.03	0.7	-0.66	1.17	-1.55	-0.18	0.45	-0.8	1.27	0.38	0.76	0.806	0.13
SAM0-UNICON	0.28	0.45	0.19	-0.31	1.48	-0.98	0.09	-0.71	0.54	1.14	-0.28	-0.89	-1.09	-1.45	-0.31	0.64	1.42	0.22	-0.16	-0.26	0.6445	0.15
BCC-CSM2-MR	-0.74	0.01	-1.62	-0.02	1.7	-0.63	-0.51	0.27	1.53	0.51	-0.41	-1.43	-0.83	-1.13	-0.31	1.59	1.67	0.57	0.12	-0.32	0.796	0.21
ACCESS-ESM1-5	-0.39	-0.15	-0.67	0.3	1	0.64	0.76	0.3	0.13	0.06	-0.25	-0.6	-0.52	-1.13	0.17	0.38	0.08	0.66	-0.64	0.15	0.449	0.14
MIROC6	5.67	-2.06	5.93	-0.28	-3.63	3.68	-0.7	-1.16	1.43	-0.07	-2.79	-1.81	-2.26	-0.63	-1.77	0.38	1.48	-2.67	-1.4	2.92	2.136	0.6
MPI-ESM1-2-LR	-0.8	0.1	-0.73	0.01	1	0.54	-0.41	0.24	1.11	0.7	0.16	-1.08	-1.18	-2.09	-0.37	0.7	1.83	0.79	-0.8	0.6	0.762	0.17
NASA GISS	1.33	-0.98	1.96	0.39	-0.77	0.64	-0.45	0.62	-0.32	0.22	-0.16	-1.14	-1.37	-1.45	-0.94	2.26	0.28	-1.59	-0.64	2.12	0.9815	0.45
CMIP6 Mea	1.46	-0.68	1.78	0.29	-0.26	0.94	-0.19	-0.38	0.51	0.11	-0.85	-1.13	-1	-1.13	-0.67	0.73	0.79	-0.48	-0.71	1.02	1.12	0.32

... with: Michelle Gore (PSU), Melissa Gervais (PSU)

Thoughts…

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- Coupled model resolution is critical!
  - Small-scale storm structure within coastal cyclones important for precipitation and wind credibility
  - Even in NEUS, complex basin topography important for precipitation phase + runoff
  - High-resolution atmospheric forcing only as good as land, ocean surfaces…
- Metrics and data analysis take center stage!
  - Need to define objective ways of evaluating storm-scale processes
    - Ex: TCs have historically been "wild west"
  - Workflows/data sharing/archival need to account for rapidly growing size
  - Interpretability!