Evaluating the Spread of Climate Model Ensembles Based on Computing Environment Selection

Tom Robinson

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Outline

- Motivation
- Ensemble method
- Ensemble description
- Ensemble spreads and comparison
- Conclusions

Motivation

- Reproducibility is important
- Floating point and rounding differences between runs prevents bit-for-bit reproducibility
- “Climate answers” are dependent on the selection of platform/compiler (options)
- What is the “model spread” due to rounding error?
- Is the model spread platform dependent?

Ensemble Method

- GFDL AM4 (github.com/NOAA-GFDL/AM4)
- Simulate rounding error
  - Single random point
  - Initial mid-level T 10^{-13} K
  - Different point for each ensemble member
- Model run for one year

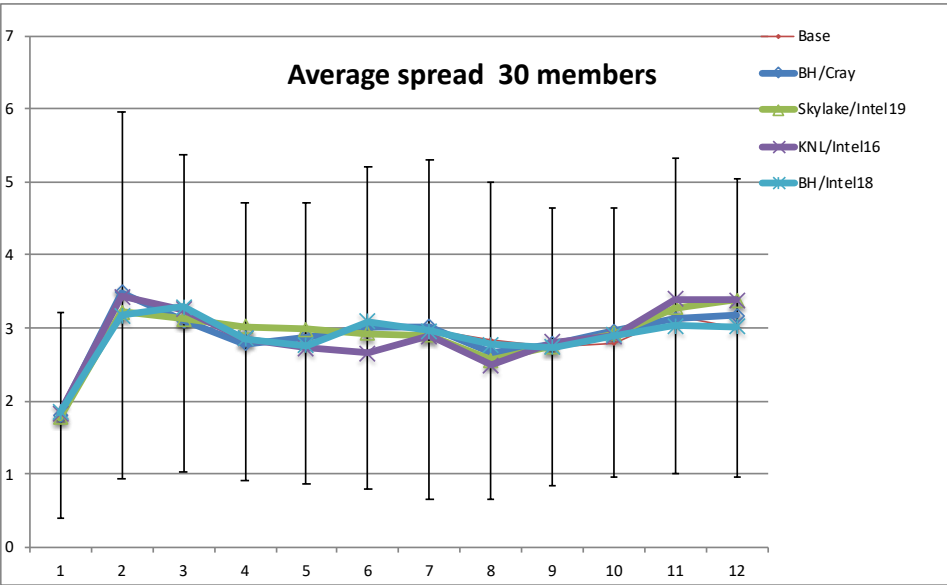
Ensembles

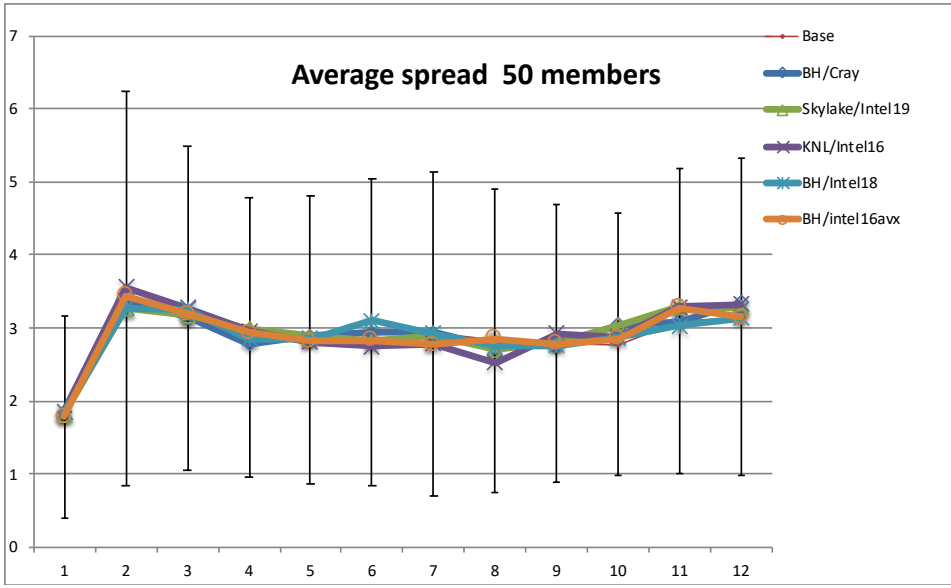
Ensemble Name	Compiler	Platform	Processor	# of ensembles
Base Production	intel 16	Gaea	B/H	300
AVX	intel 16	Gaea	B/H	100
Intel 18	intel 18	Gaea	B/H	100
Cray	cray	Gaea	B/H	95
Theta	intel 16	theta	KNL	118
Hera	intel 19	Hera	Skylake	47

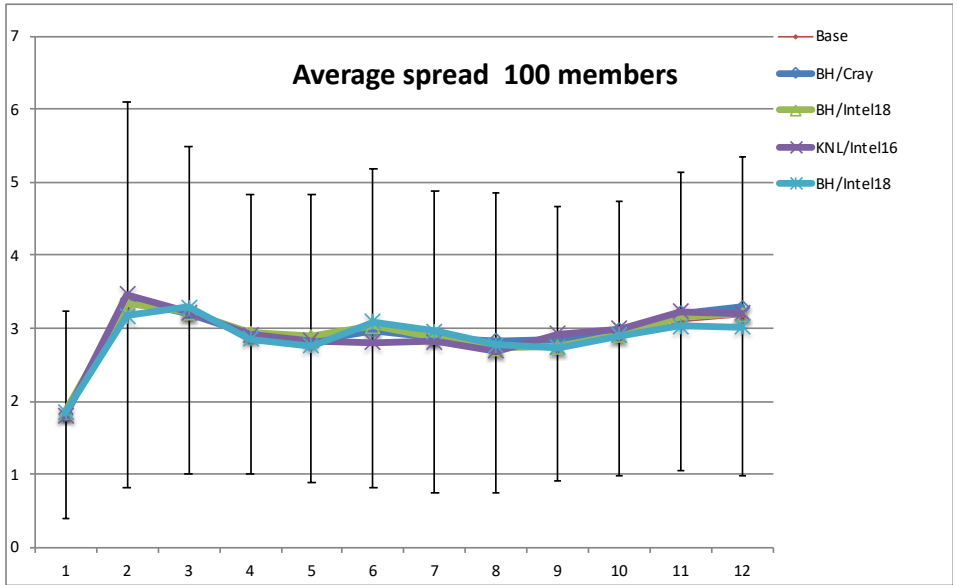
Average standard deviation

- Find the point-by-point standard deviation
  - Take a global average
    - Plot and compare
  - Point by point mean
    - Are the means similar?
  - Point by point standard deviation
  - Compare across ensembles
    - Is spread platform dependent?

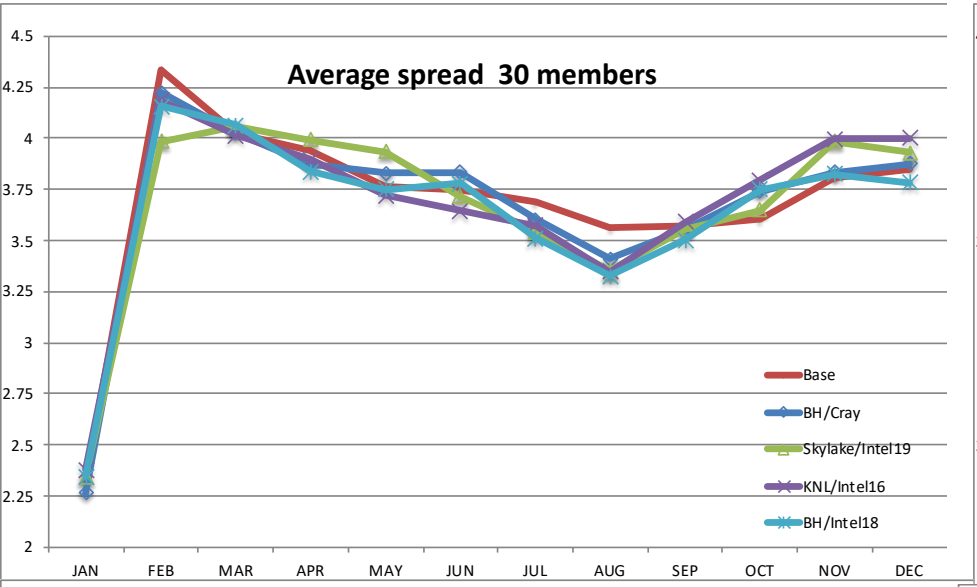
Global Spread Surface Pressure

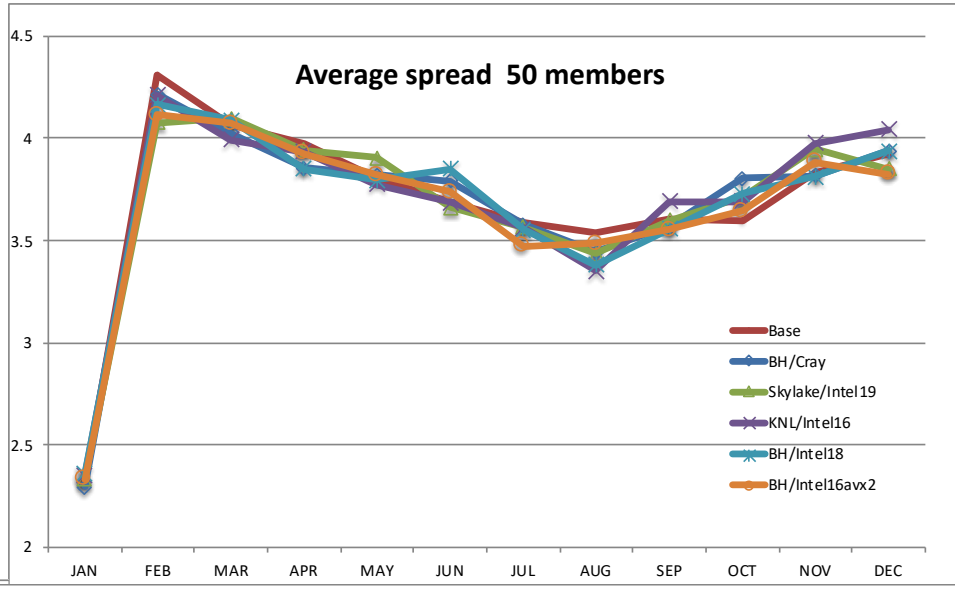


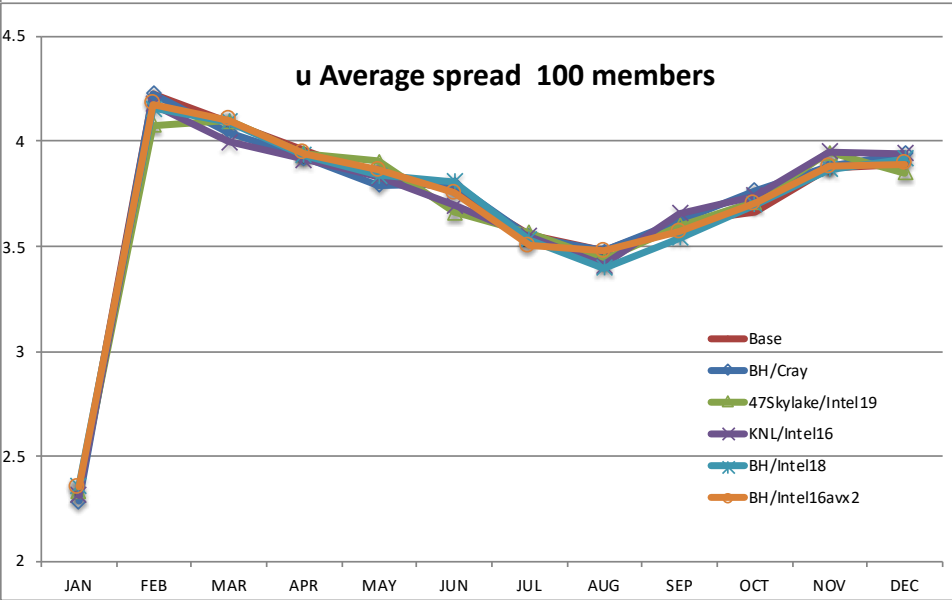


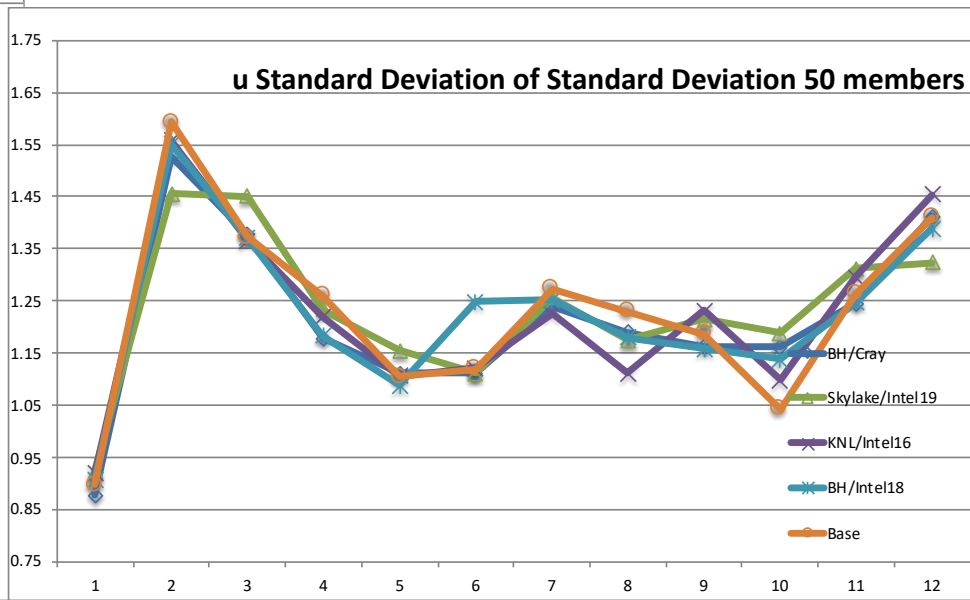


Global Spread U wind

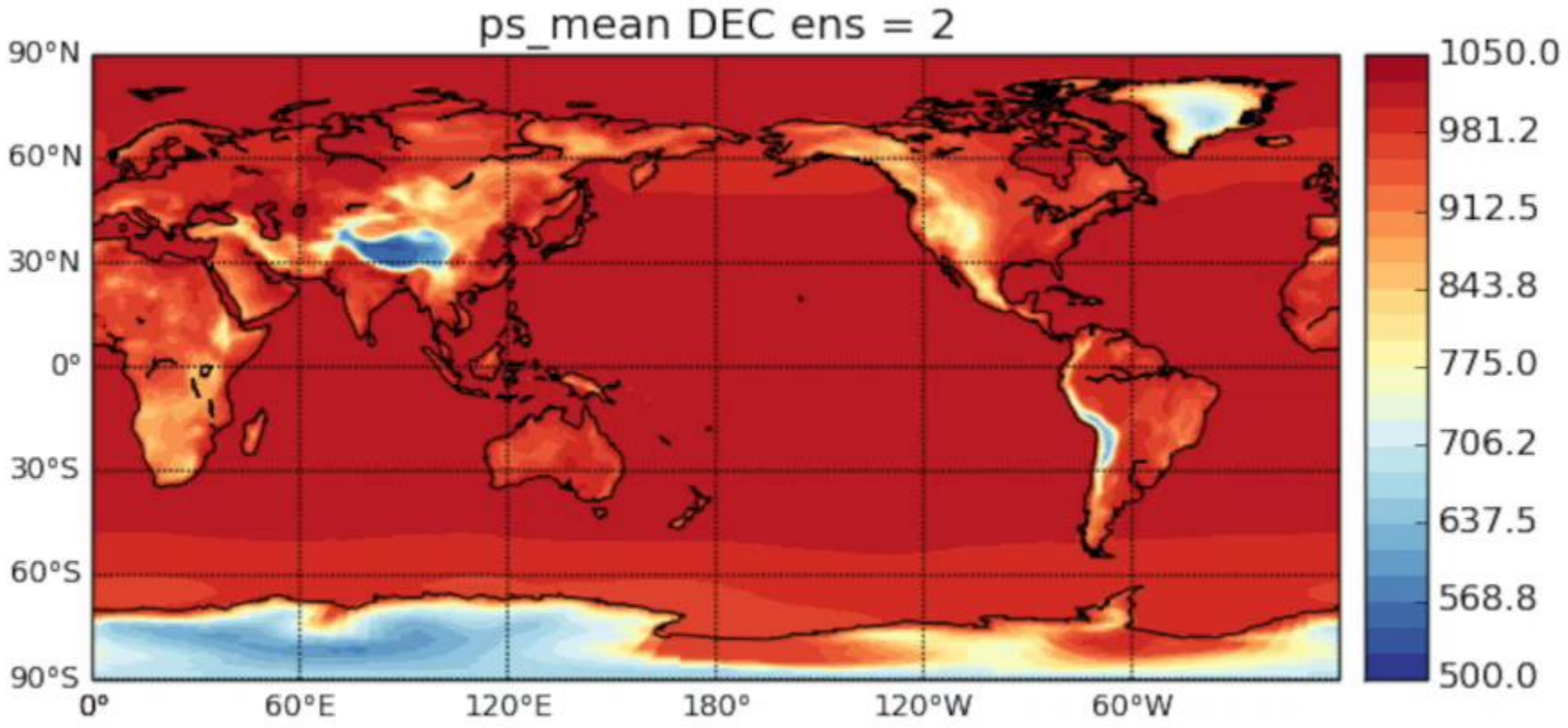




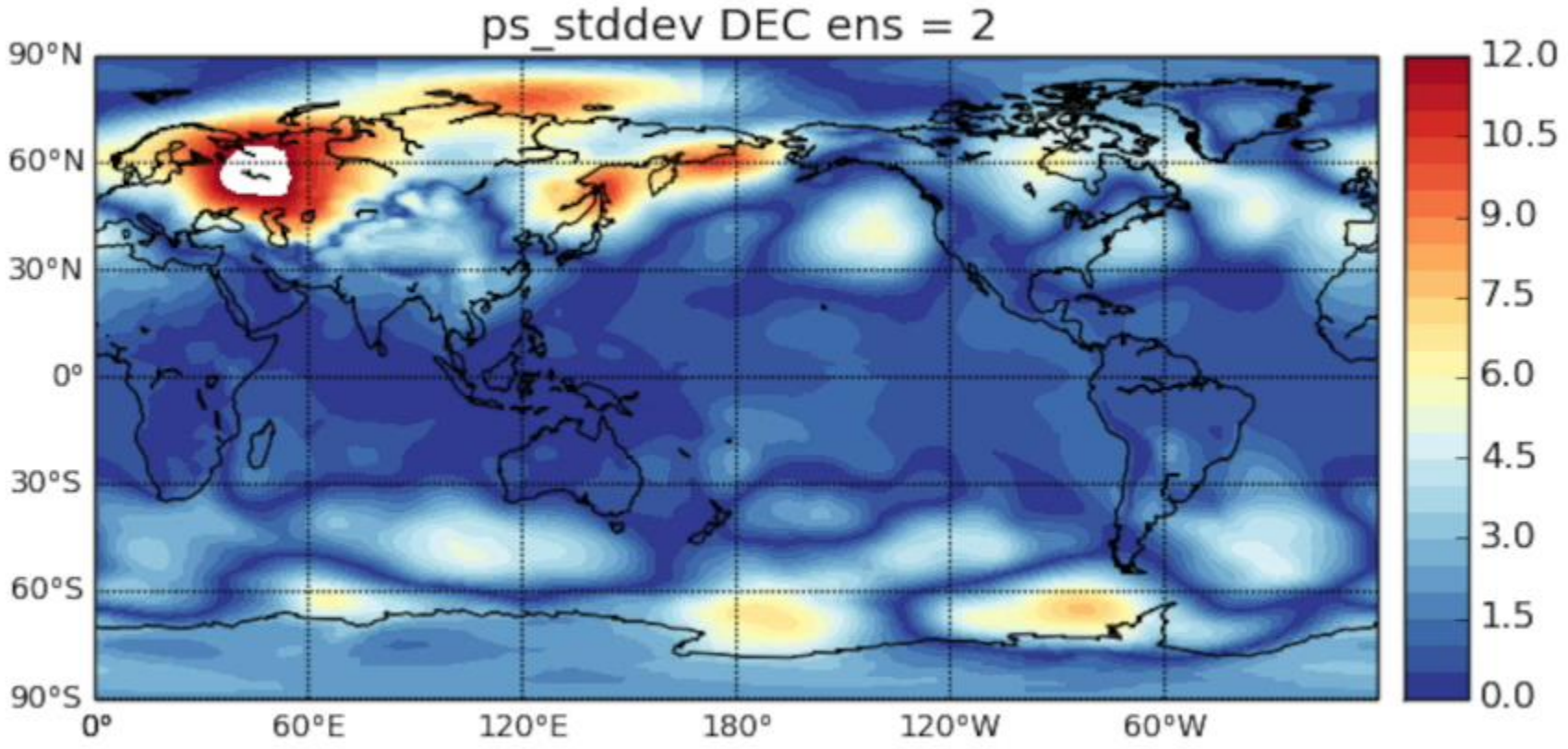




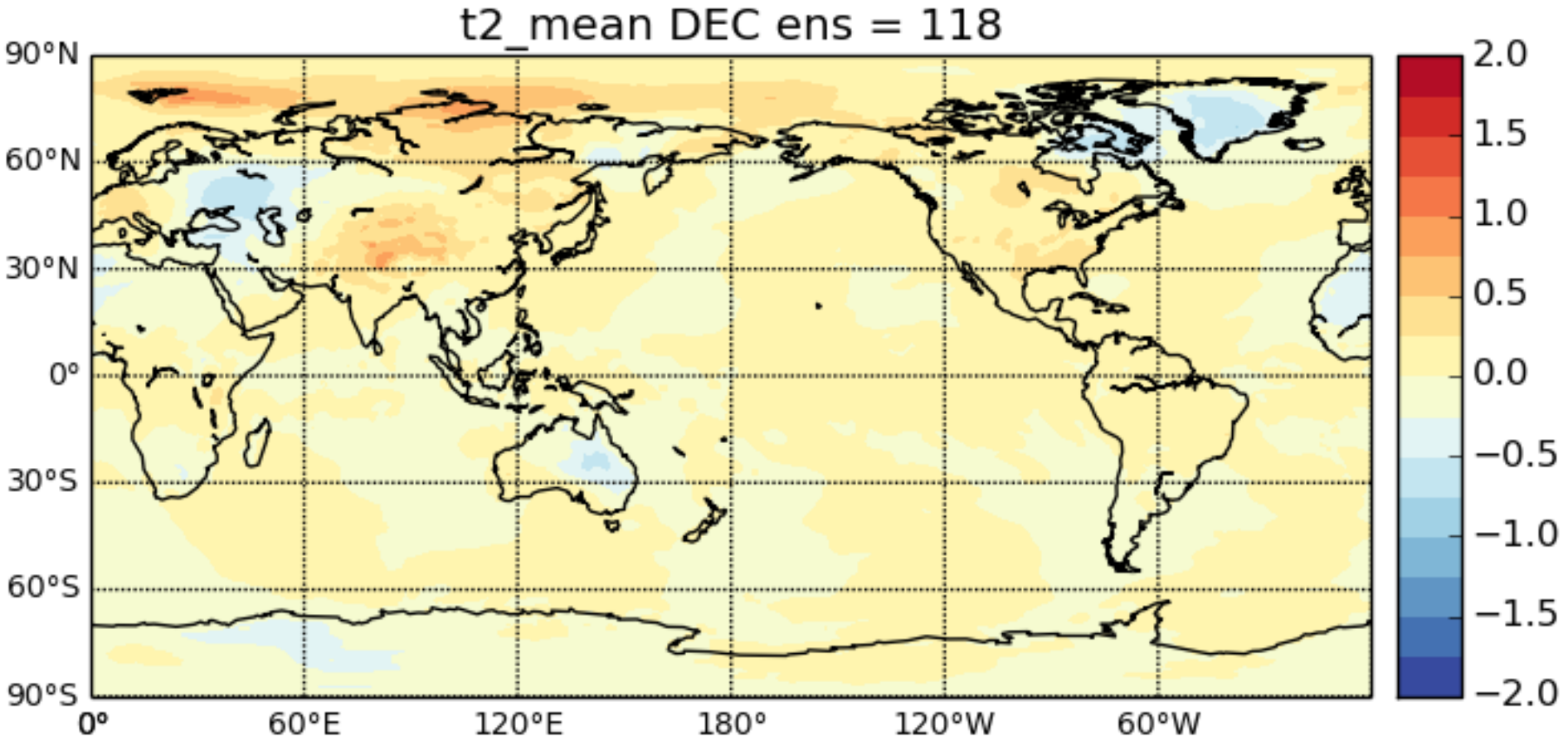
Mean ps (base)


ps_mean DEC ens = 2
90°N
60°N
30°N
0°
30°S
60°S
90°S
0°
60°E
120°E
180°
120°W
60°W
1050.0
981.2
912.5
843.8
775.0
706.2
637.5
568.8
500.0

ps Standard Deviation

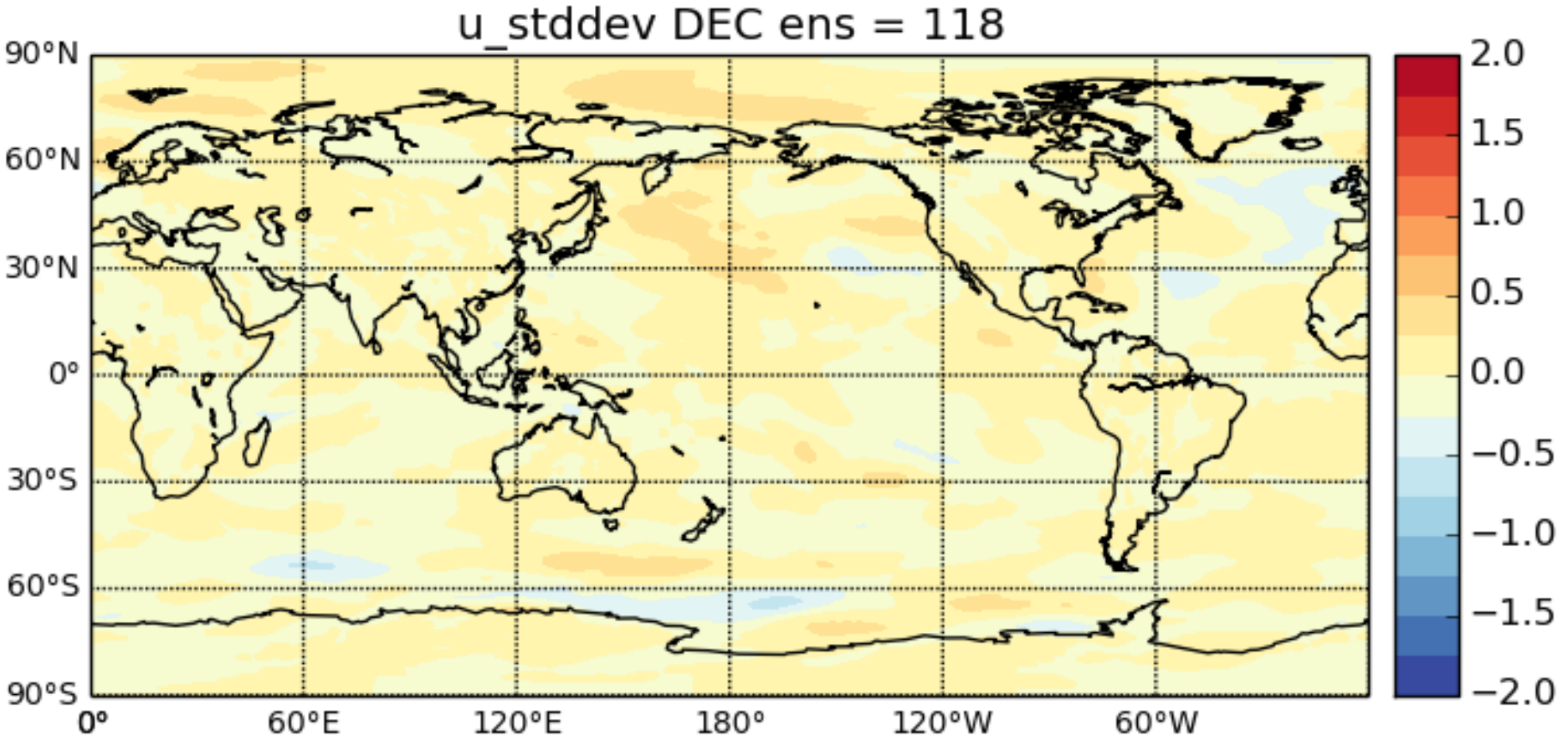


KNL-Base Mean Difference

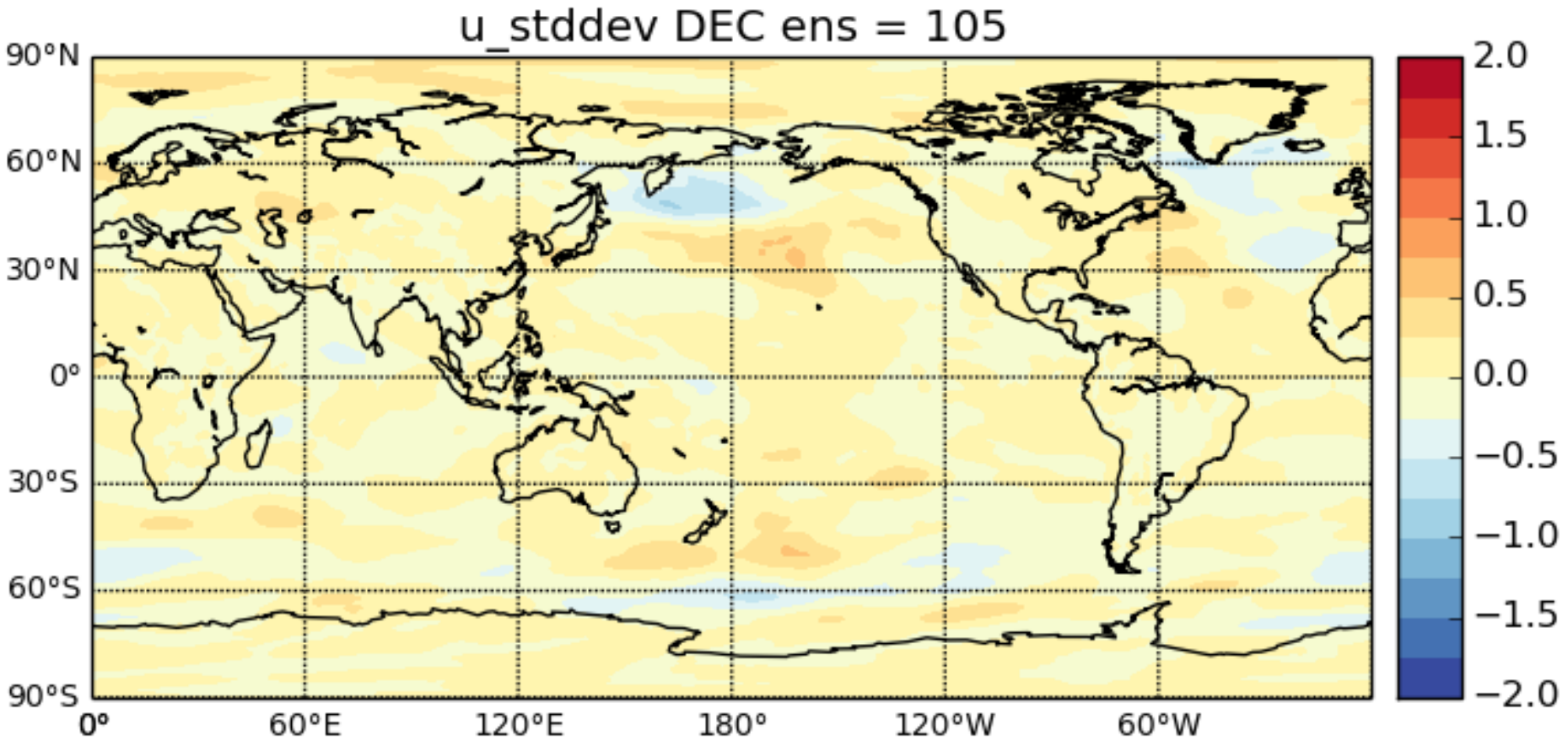


*All values within 1 standard deviation

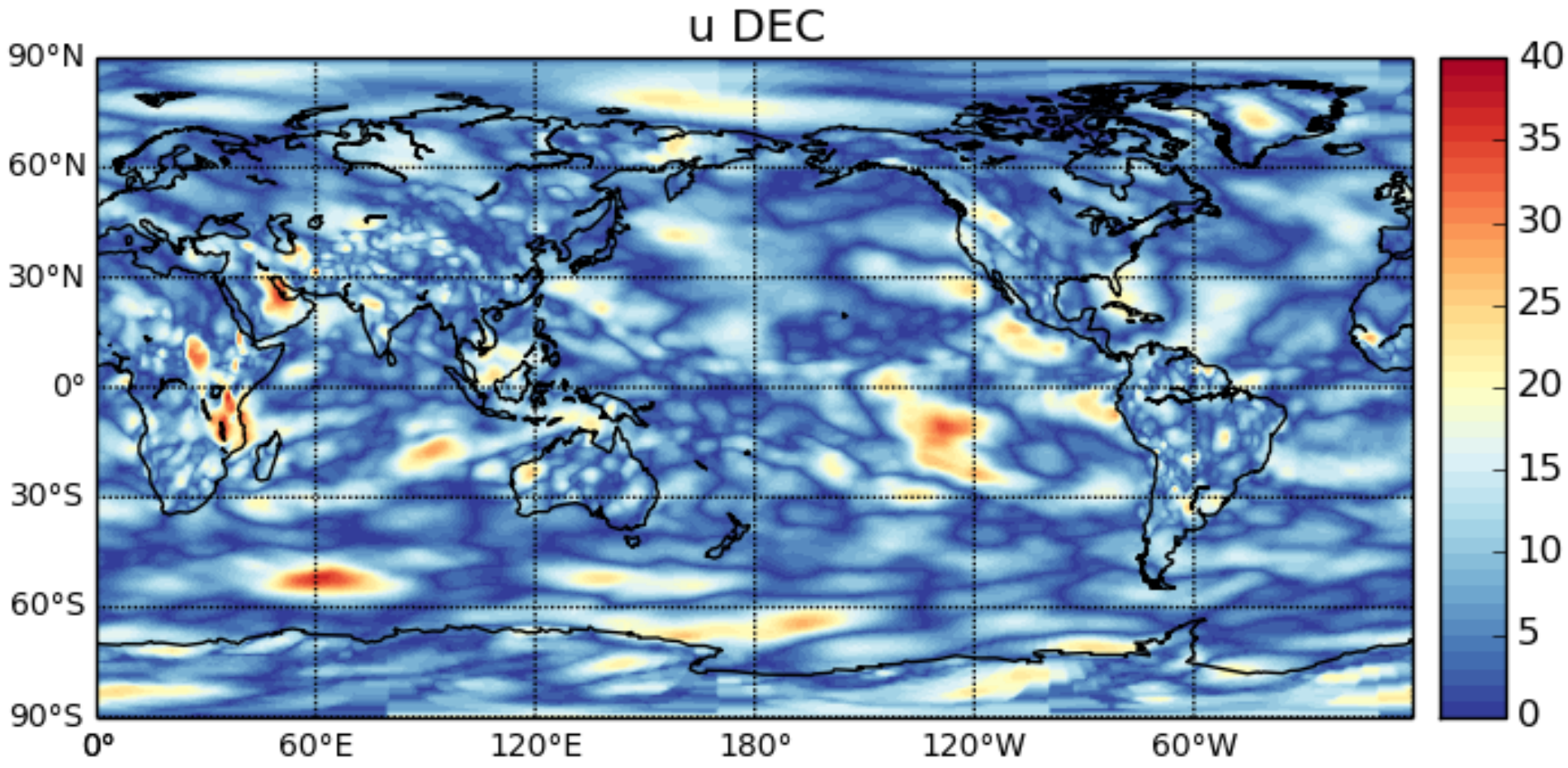
Standard Deviation Diff (theta-base)



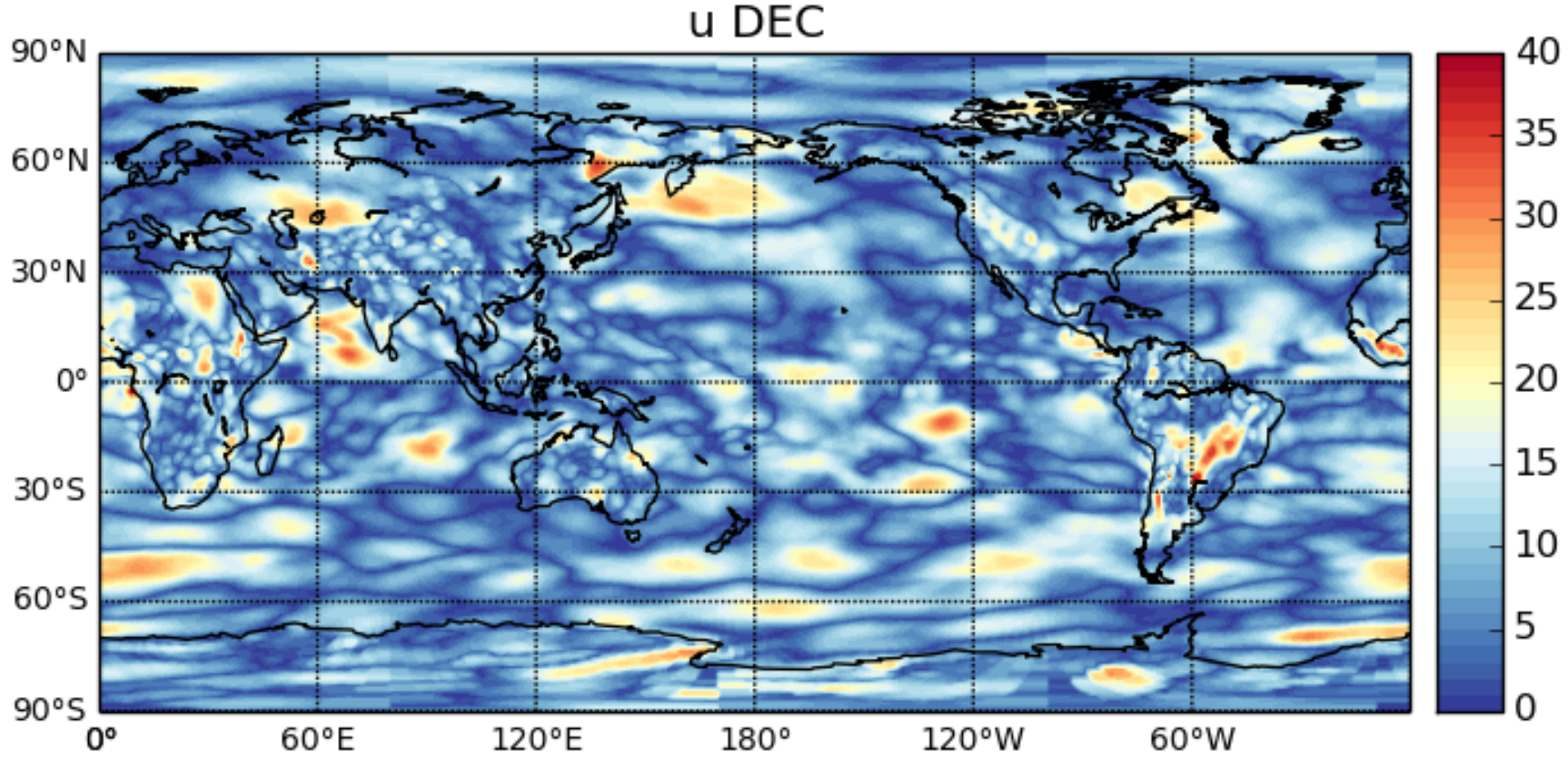
Standard Deviation Diff (cray-base)



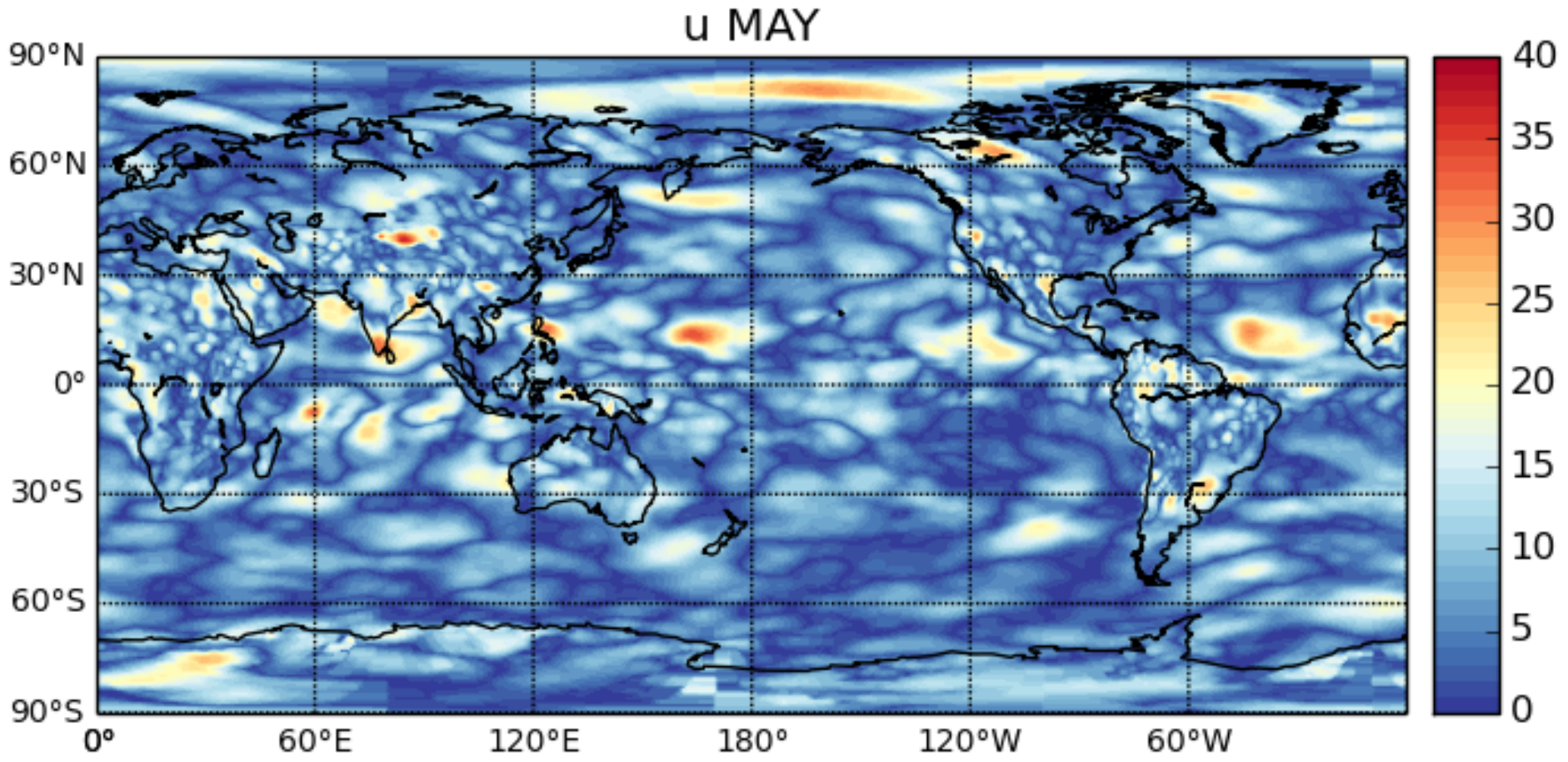
Standard Deviation %Diff (KNL-base)



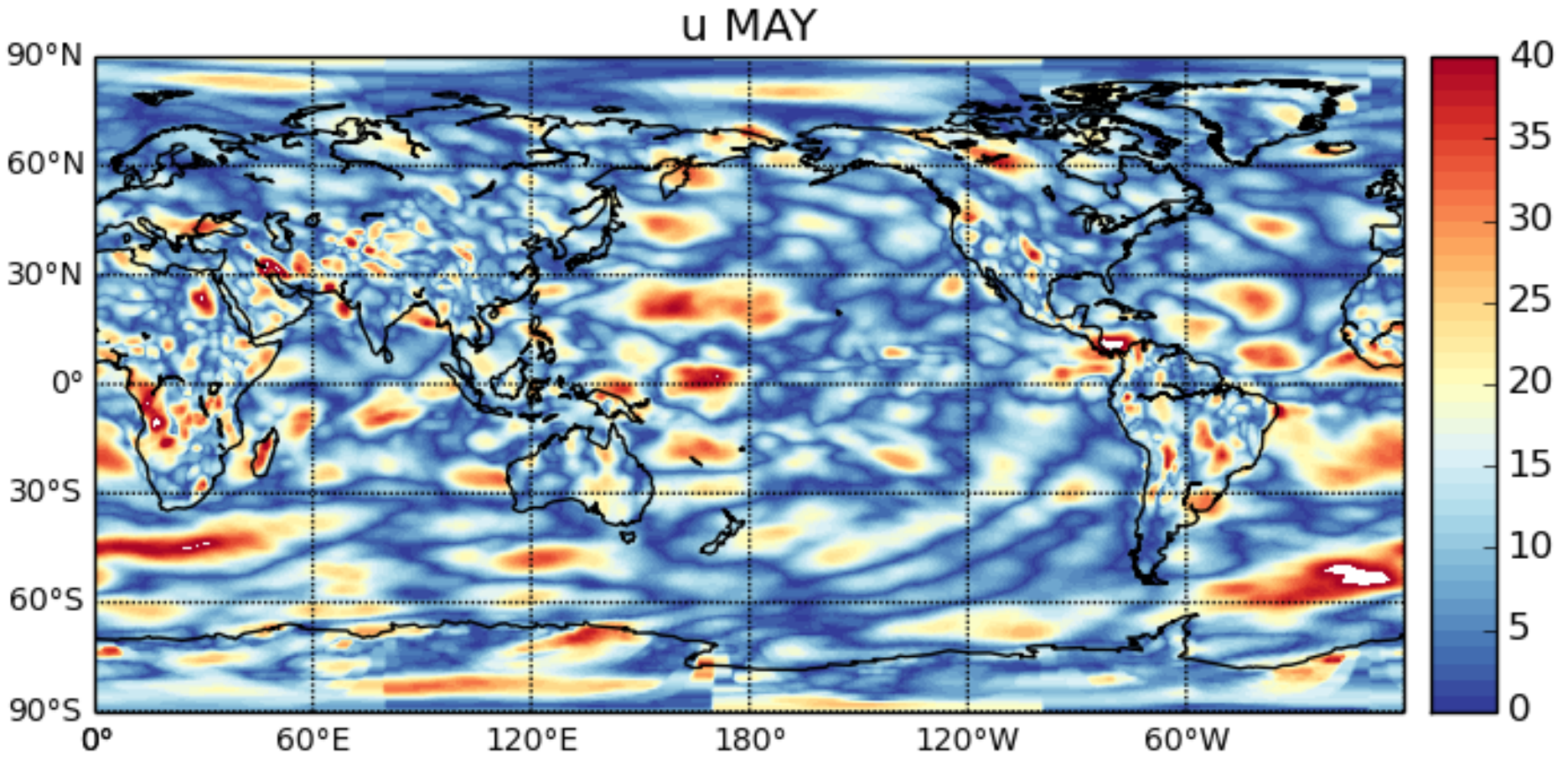
Standard Deviation %Diff (cray-base)



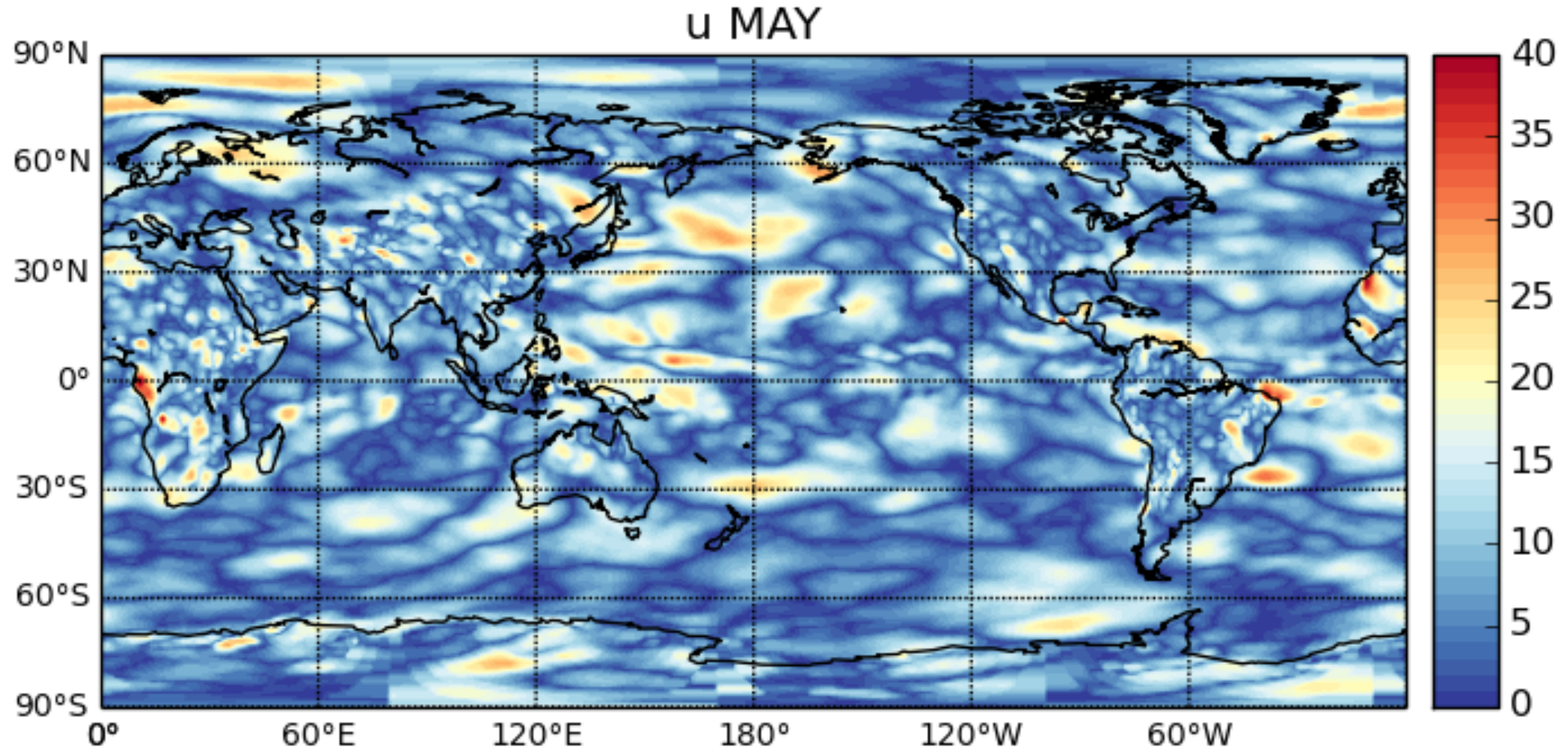
Standard Deviation %Diff (KNL-base)



Standard Deviation %Diff (skylake-base)



Base30-Base %diff



Conclusions

- Ensemble means are not platform dependent
- Ensemble spreads over a local region are platform/compiler dependent
- You should use a large ensemble to report the error due to rounding on your computing platform.
  - Global Average for summary
  - Map of values for patterns/weaker areas