Stellopt Convergence Study

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Wistell Meeting, Mar 30, 2018

Goal is to determine if the search space is "locally convex"

A set, $S \in \mathbb{R}^n$ is convex, if for any points, $x_1, x_2 \in S$, the straight line joining x_1, x_2 lies entirely in S
A function f is convex if its domain, S is a convex set, and:

$$f\left(\alpha x + (1-\alpha)\, y\right) \leq \alpha f(x) + (1-\alpha)\, f(y)\, \forall\, \alpha \in [0,1]$$

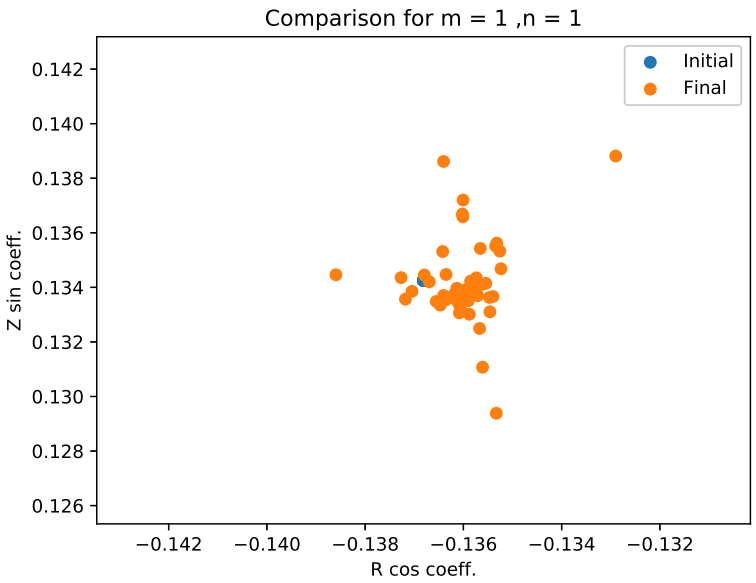
f is locally convex if it is convex for some region of space
When considering solutions to convex functions of the form $f : \mathbb{R}^n \to \mathbb{R}$, if f is locally convex then a local solution is a global for that region of space. This means algorithms based on following descent paths will yield global solutions.

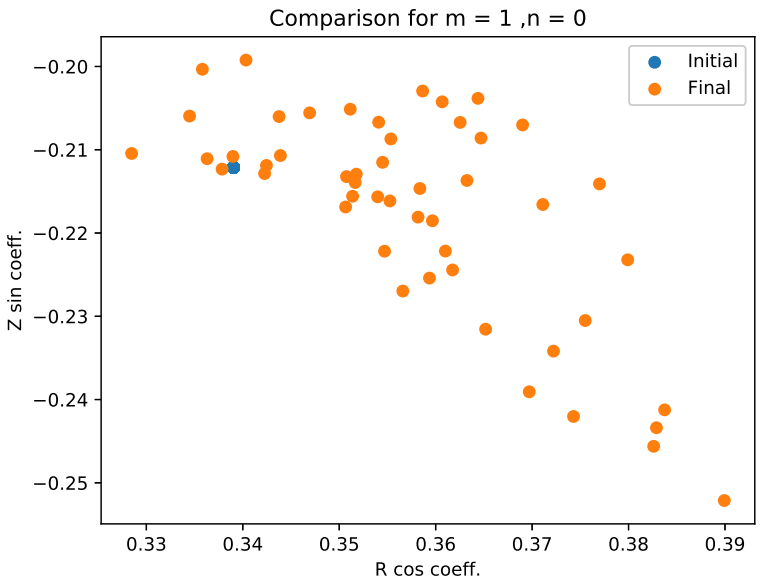
Question: Is our space locally convex?

A simple test for local convexity

- Begin points with slightly varying initial conditions
- Optimize points with a deterministic descent algorithm (LM in our case)
- Catalog where the points end up, convex functions will all wind up in the same place
- Change variation amount and repeat
- Details: vary modes with $-3 \leq m \leq 3; - \leq n \leq 3$
- Optimize for quasi-symmetry, aspect ratio and neoclassical transport
- Approx. 50 initial points chosen for the scan
- Variations of 0, 5 and 10% of the initial coeffs, not varying the $m = 0, n = 0$ mode

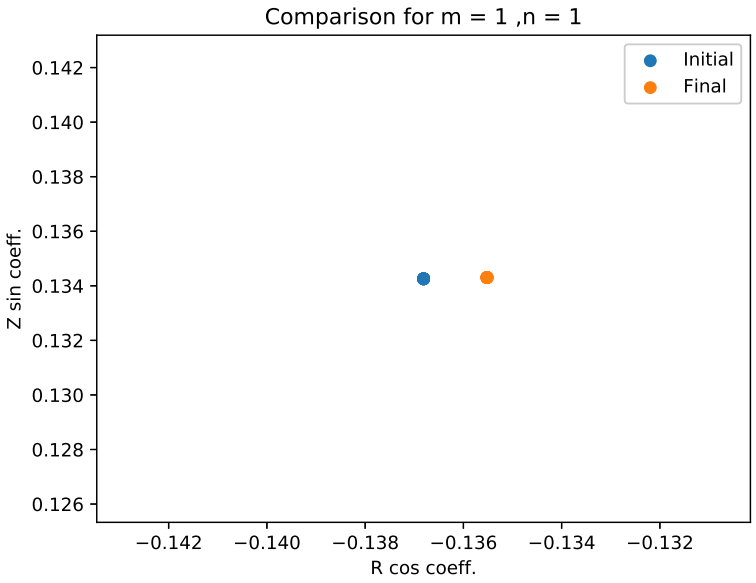
Bug Alert!! 0% variation are in different places

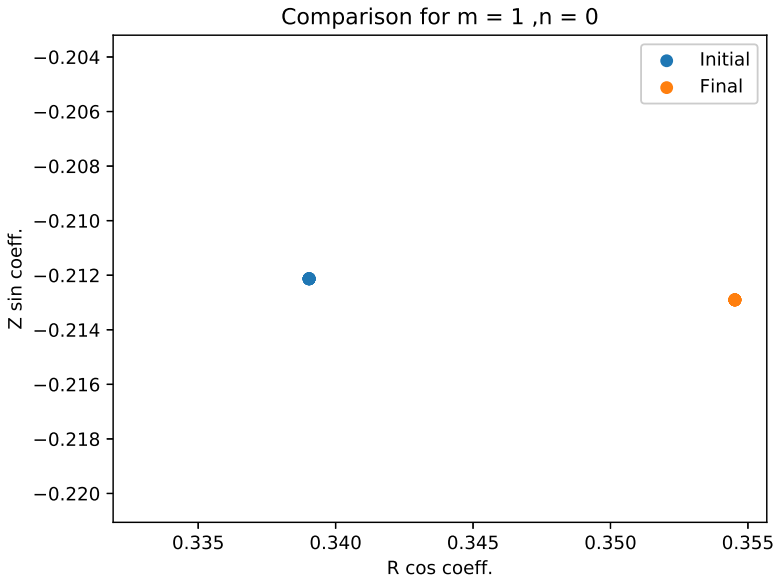




Final answers should not vary at all, but they do.

Bug busted - 0% variation behaves correctly



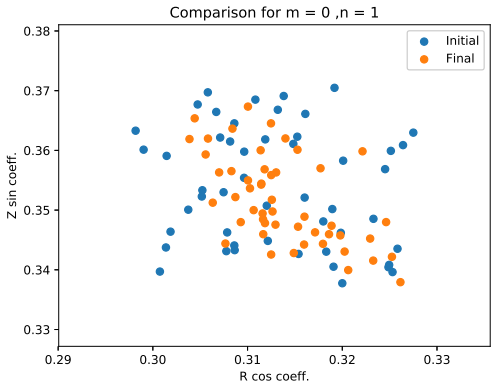


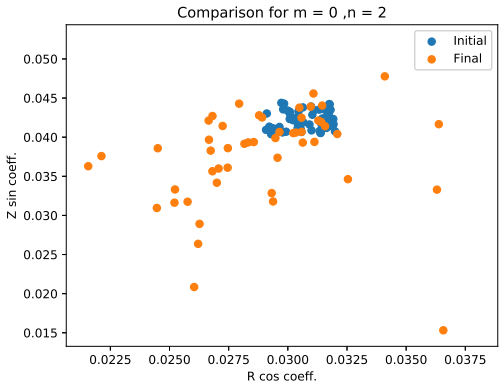
Bug relates to junk getting written into unused coefficients.

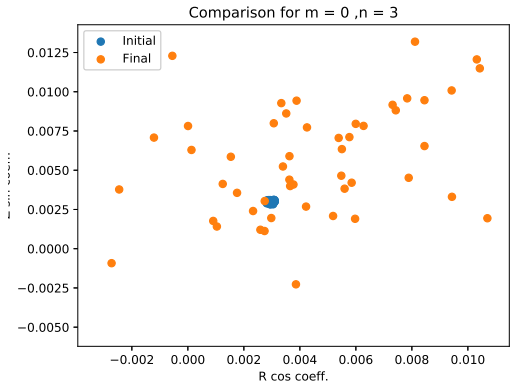
Solution: make sure VMEC only solves for the same coefficients as specified in the optimizer.

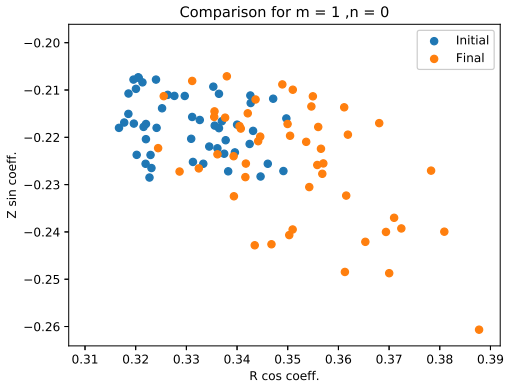
Junk values did not show up in the saved VMEC output, which is why this was hard to track down!

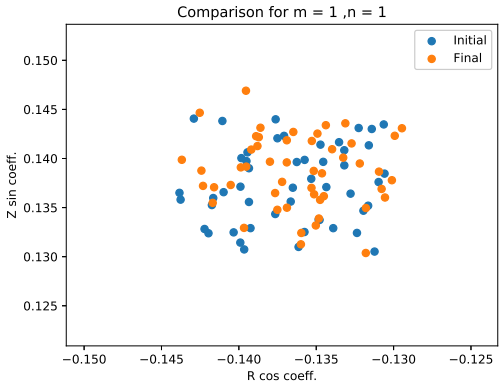
5% variation results

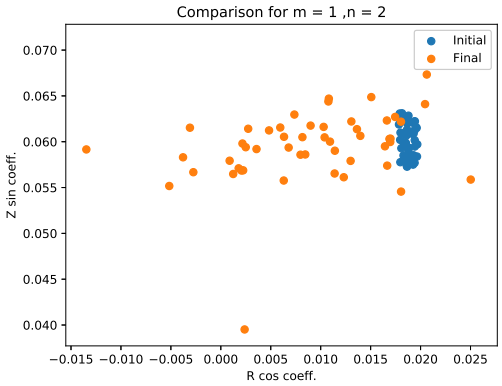




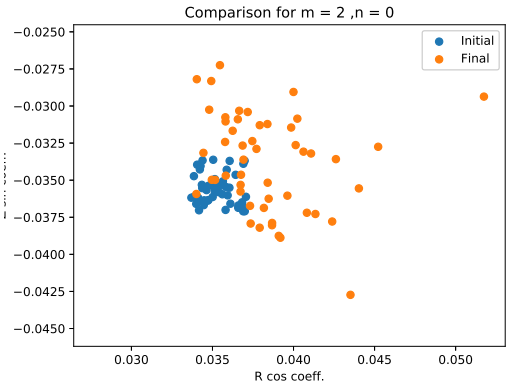


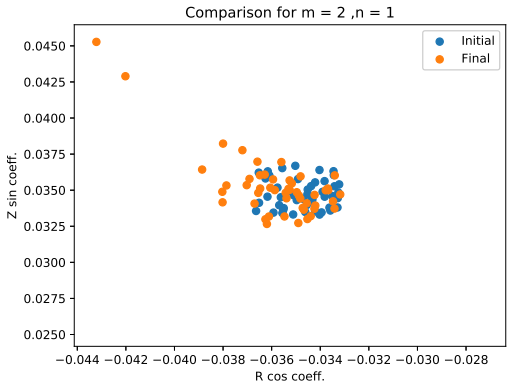


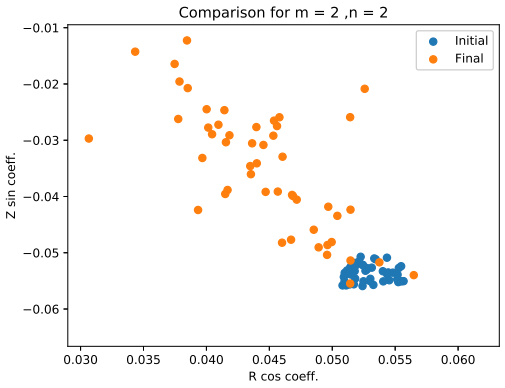


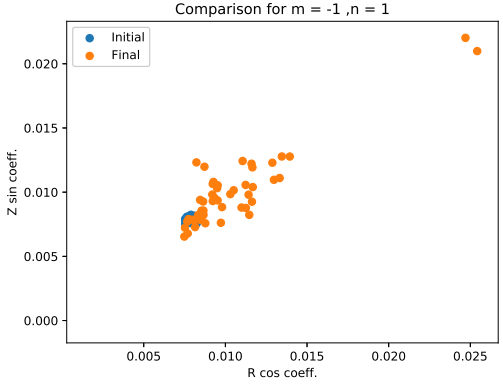


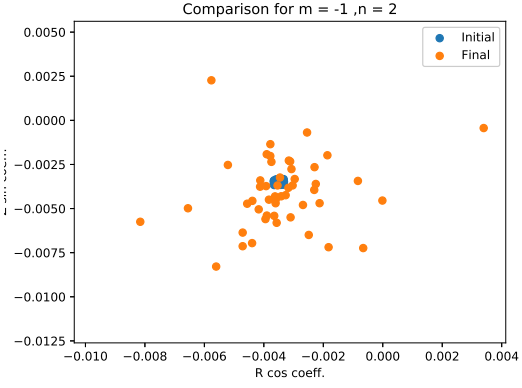
5% variation results, cont

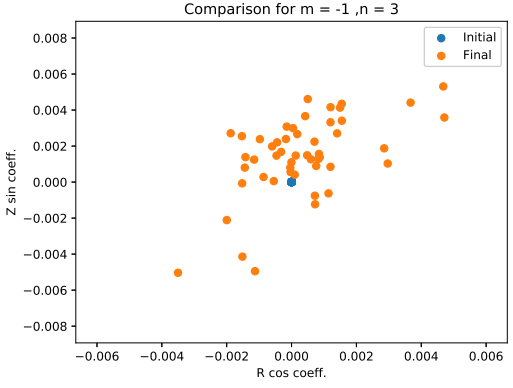




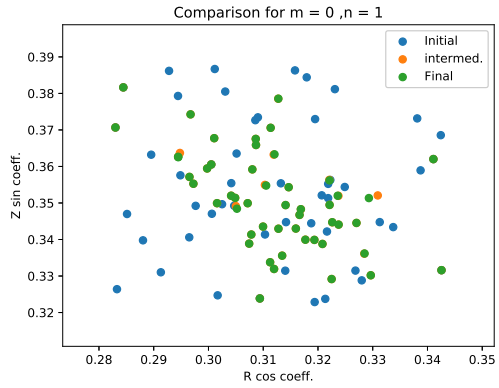


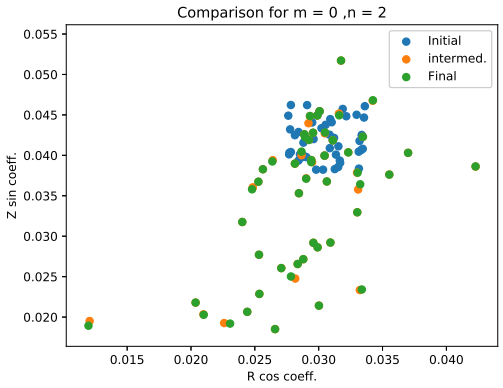


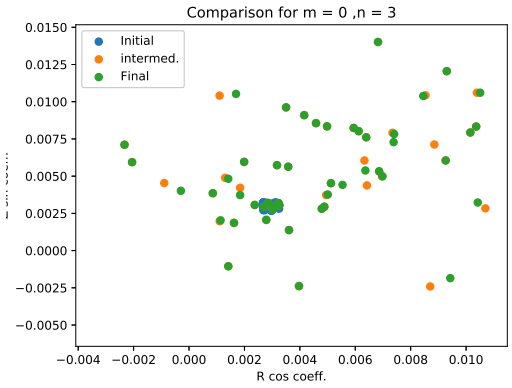


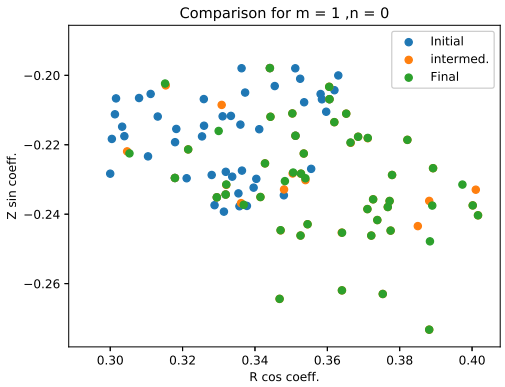


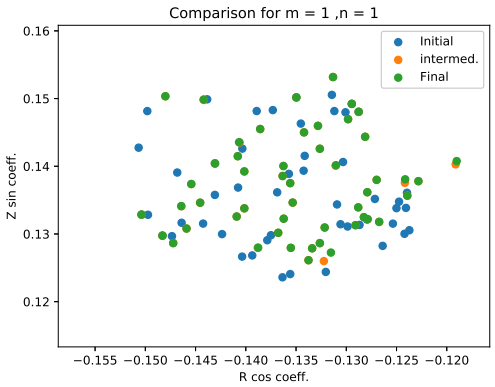
10% variation results

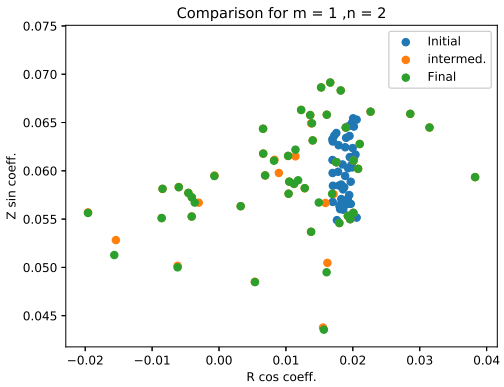




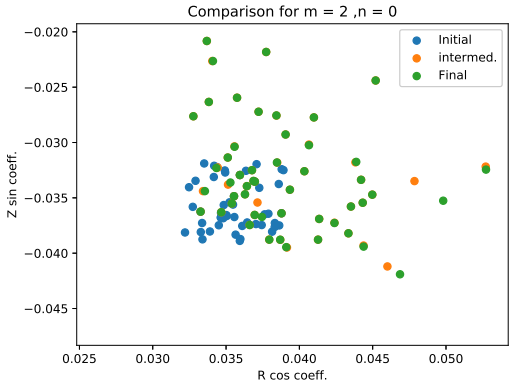


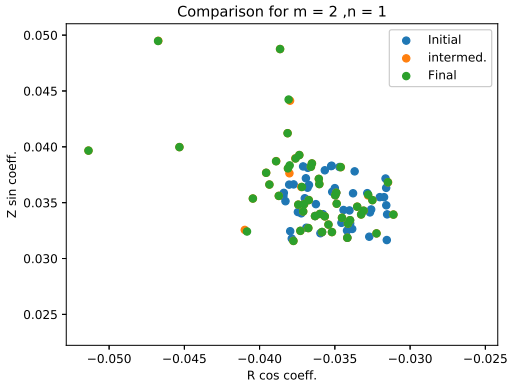


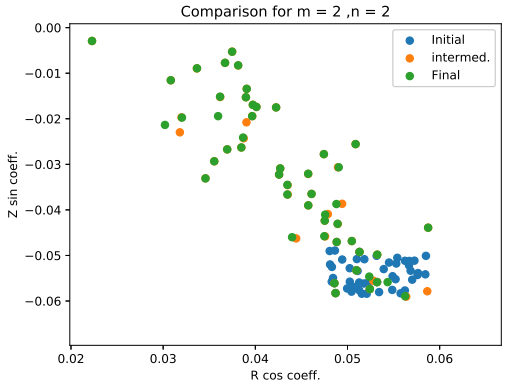


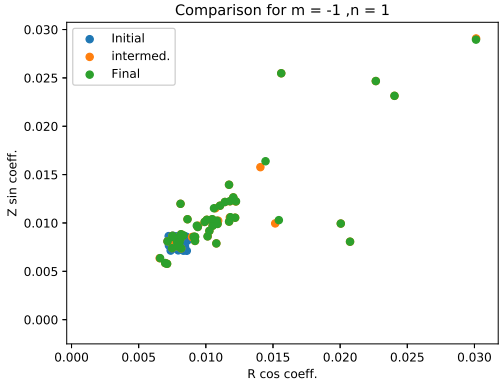


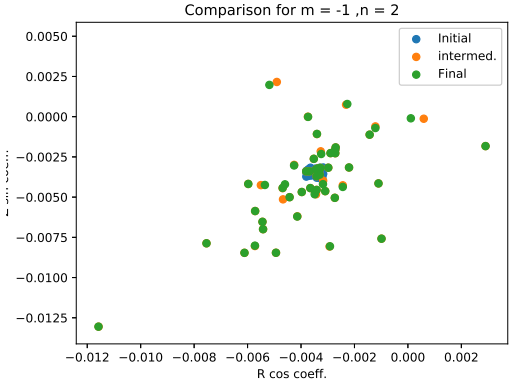
10% variation results, cont

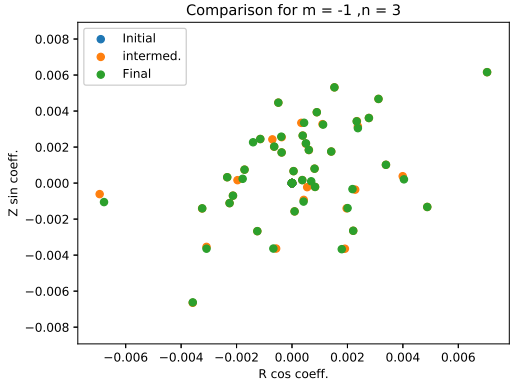












We are not convex by any reasonable metric

- In nearly all cases, final solutions cover a larger area than the initial seeds
- It is probably worthwhile to keep/regenerate the final wout files and compare the cross sections to see how different these surfaces are
- I can try smaller variations, but I have a feeling that all variations will have issues
- Caveat: I only fixed the bug on Thursday, so the final results were a bit rushed. I could have made an error
- Where to go from here?