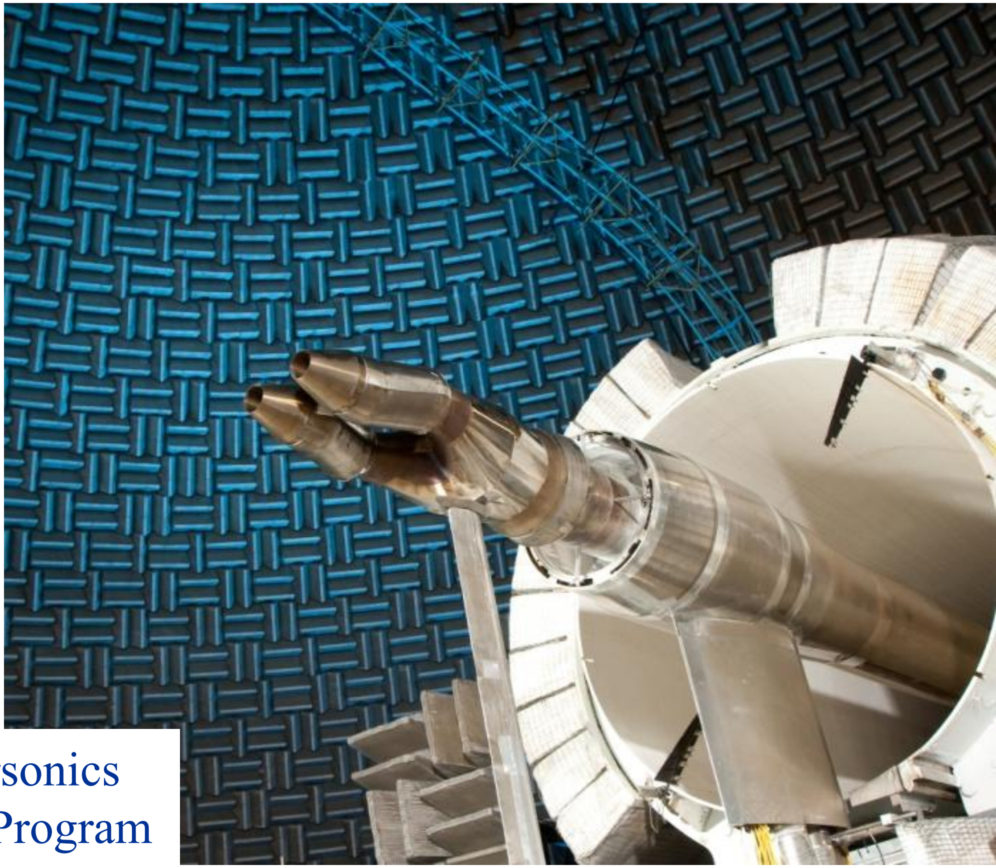
The Impact of Subsonic Twin Jets on Airport Noise

Subsonic and supersonic aircraft concepts proposed through NASA's Fundamental Aeronautics Program have multiple engines mounted near one another. Engine configurations with multiple jets introduce an asymmetry to the azimuthal directivity of the jet noise. Current system noise predictions add the jet noise from each jet incoherently, therefore, twin jets are estimated by adding 3 EPNdB to the far-field noise radiated from a single jet. Twin jet effects have the ability to increase or decrease the radiated noise to different azimuthal observation locations. Experiments have shown that twin jet effects are reduced with forward flight and increasing spacings. The current experiment investigates the impact of spacing, and flight effects on airport noise for twin jets. Estimating the jet noise radiated from twin jets as that of a single jet plus 3 EPNdB may be sufficient for horizontal twin jets with an s/d of 4.4 and 5.5, where s is the center-to-center spacing and d is the jet diameter. However, up to a 3 EPNdB error could be present for jet spacings with an s/d of 2.6 and 3.2.

The Impact of Subsonic Twin Jets on Airport Noise

Rick Bozak
NASA Glenn Research Center



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Outline

- Motivation
- Experiment Setup
- 1/3 Octave SPL Contours
  - Effect of jet spacing
  - Effect of forward flight
- Effective Perceived Noise Level (EPNL) Calculations
- Conclusion

Fundamental Aeronautics Program

Subsonic Fixed Wing Project N+3 NRA Concept Vehicles

Boeing

MIT

Northrop Grumman

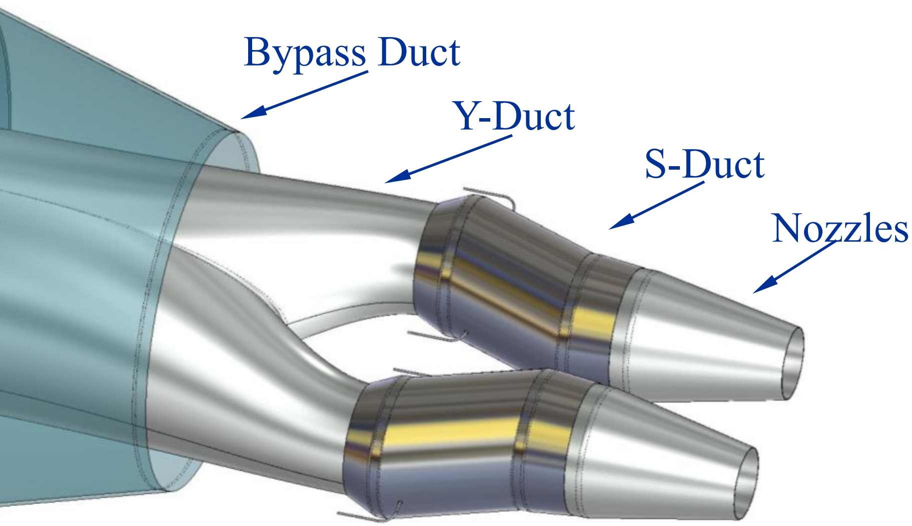
Supersonics Project Concept Vehicles

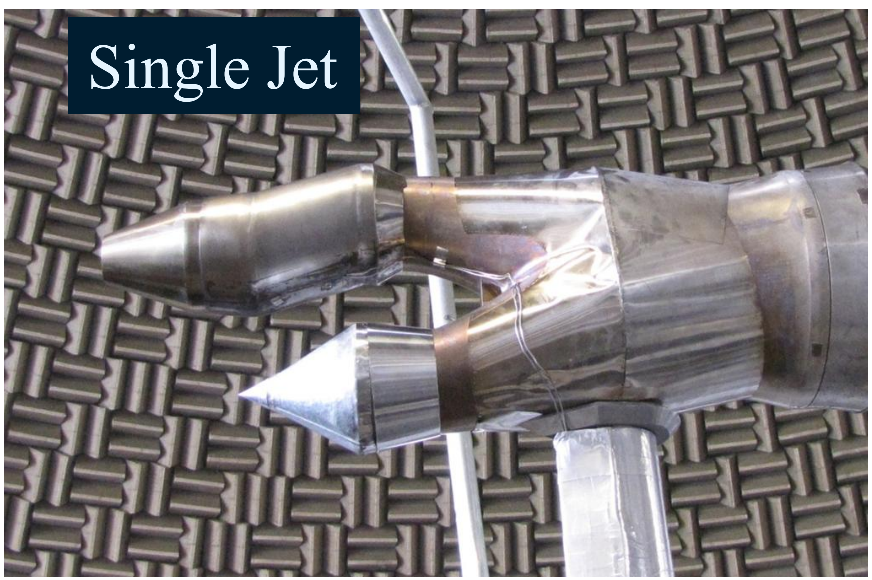
N+3, Boeing

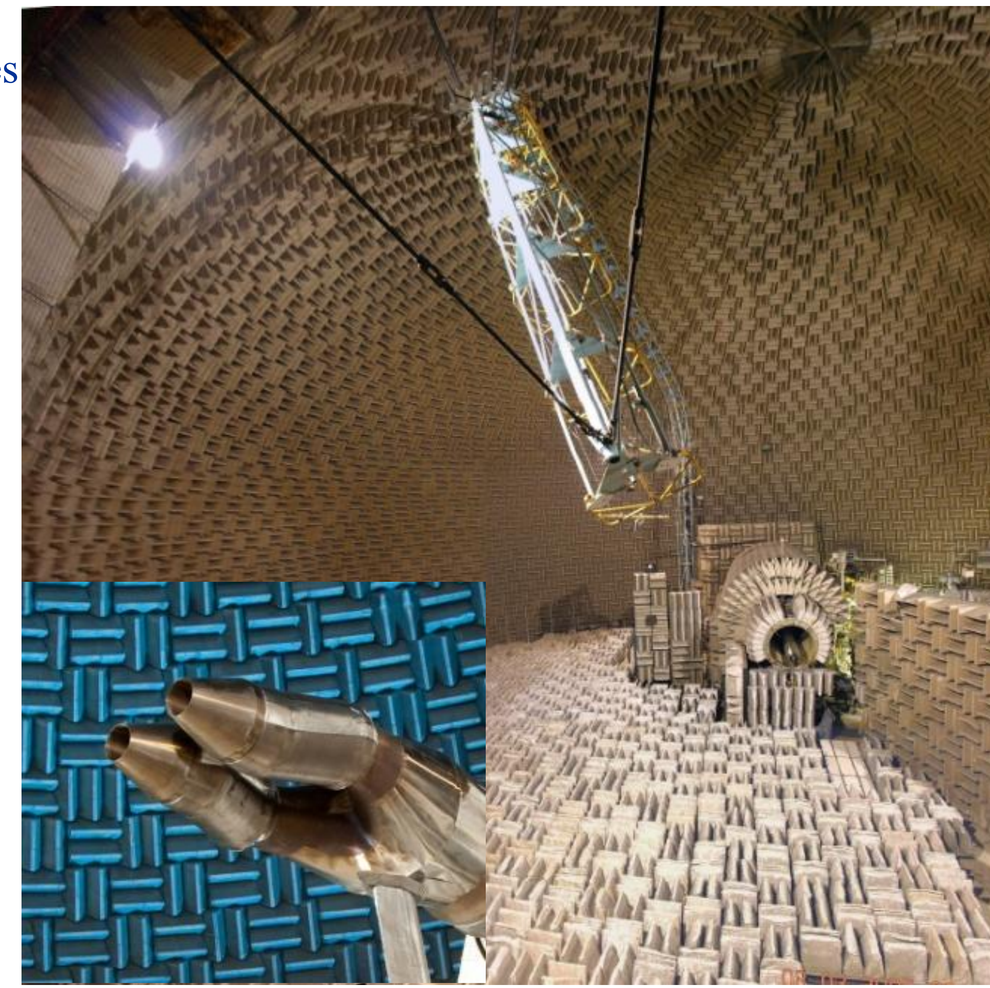
N+3, Lockheed Martin

N+2, Lockheed Martin

Configurations



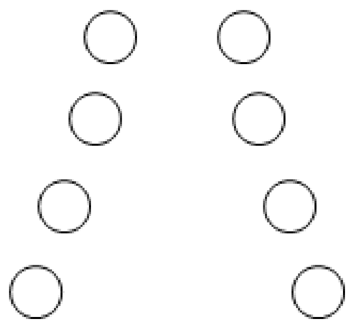




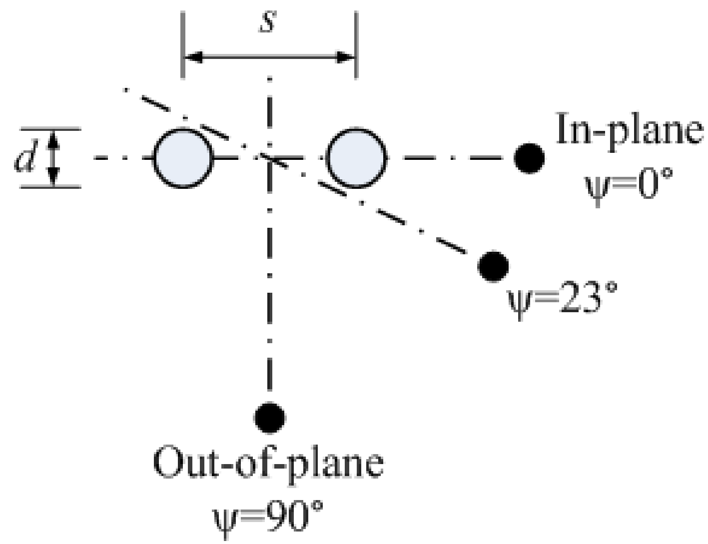
Configurations and Conditions

Spacings

s/d
2.63
3.25
4.39
5.54



Azimuthal Angles



Jet Conditions

NPR	NTR	M_{fj}
1.70	3.11	0.00
1.70	3.11	0.10
1.87	3.12	0.30

NPR= Nozzle Pressure Ratio
NTR= Nozzle Temperature Ratio
M_{fj}= Free Jet Mach Number

Sound Pressure Levels

- 2-inch conic convergent nozzles
- Actuator and diffraction corrections were made
- Background noise was removed
- Free jet shear layer refraction was corrected for
- Data are presented in 1 foot lossless 1/3 octave sound pressure levels

$$\Delta SPL = SPL_{twin} - SPL_{single+3dB}$$

Single Jet + 3dB Contour

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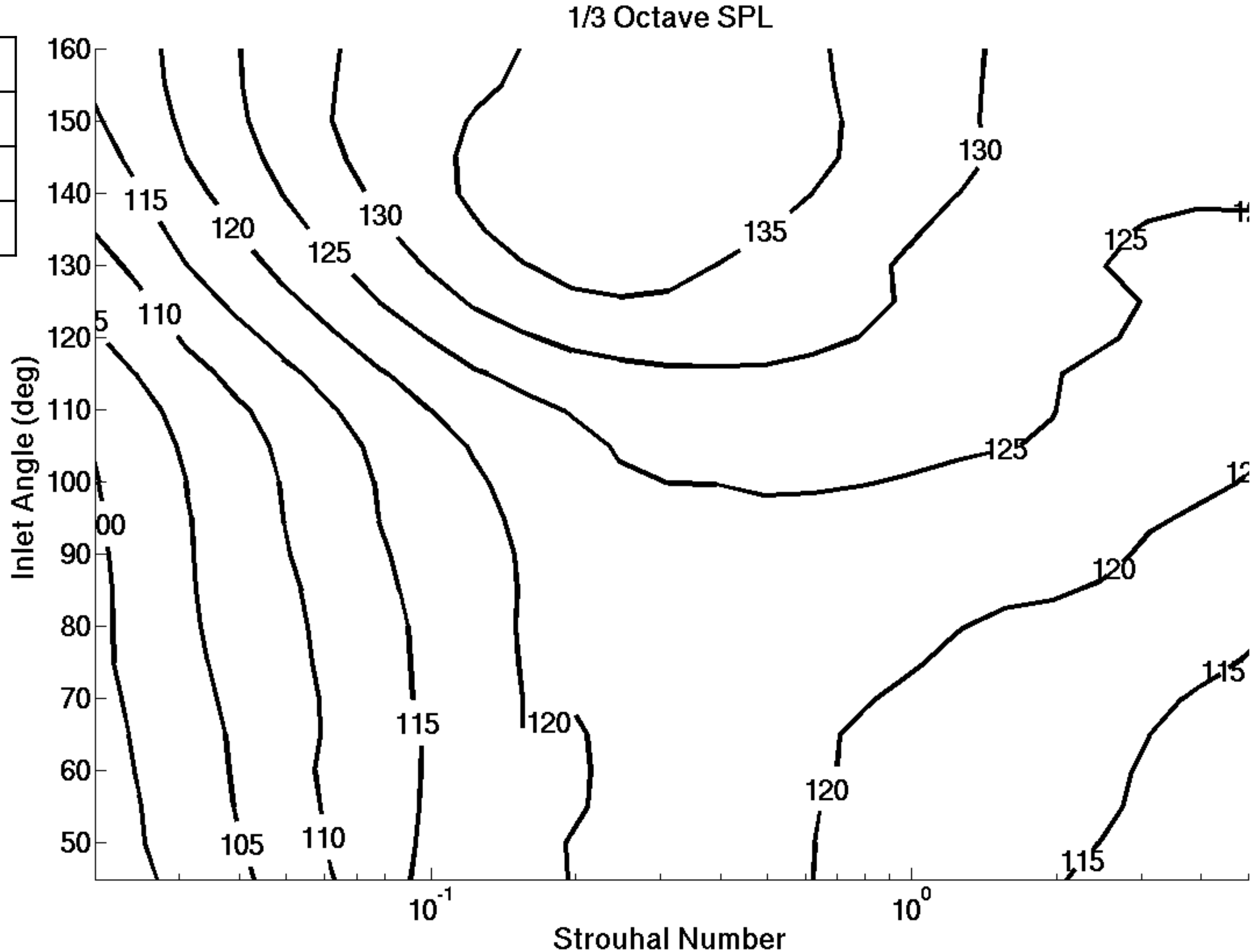

In-plane Measurements – Effect of Spacing

NPR	NTR	M_{fj}
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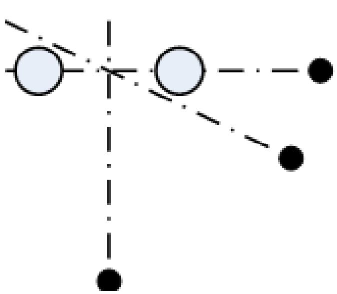

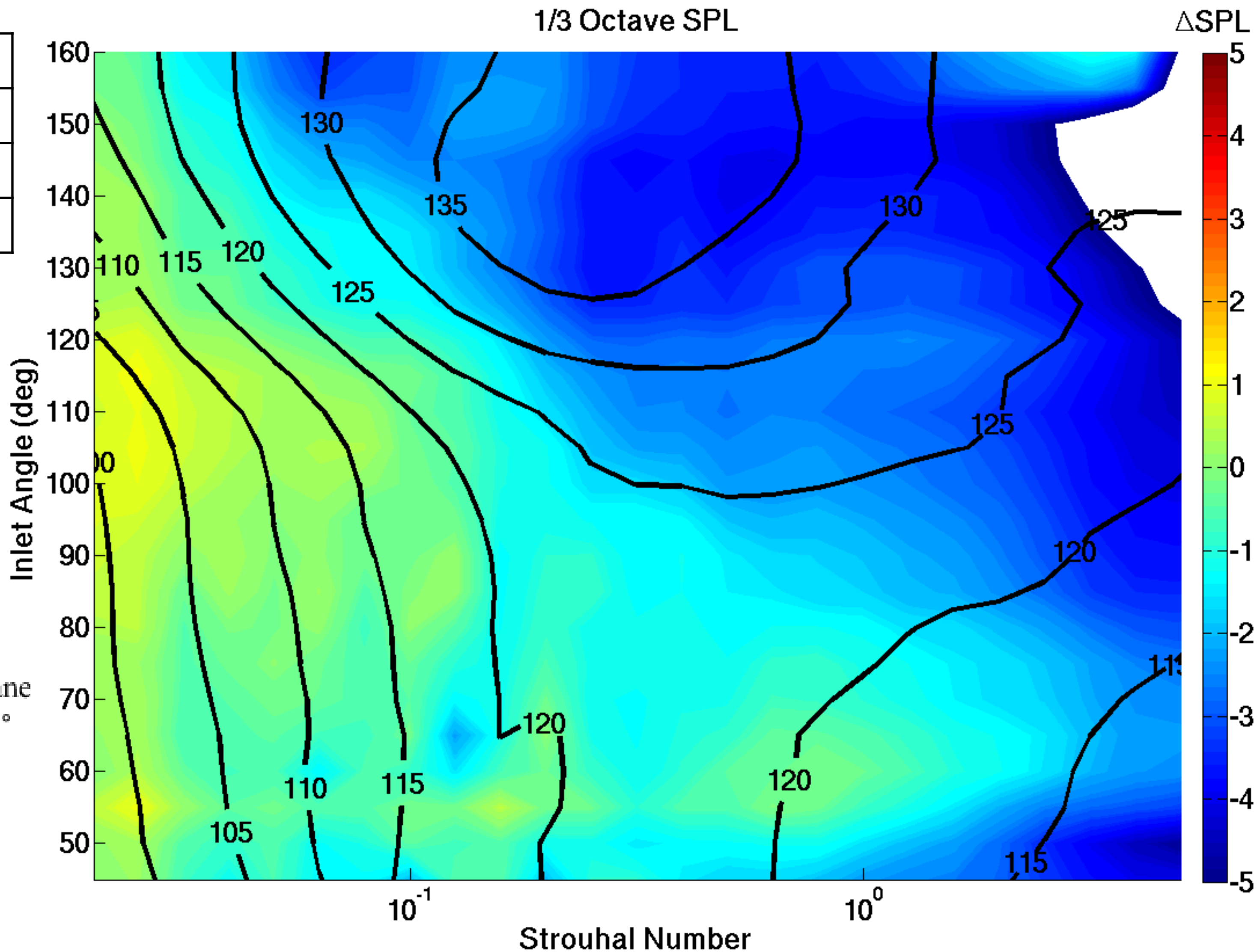

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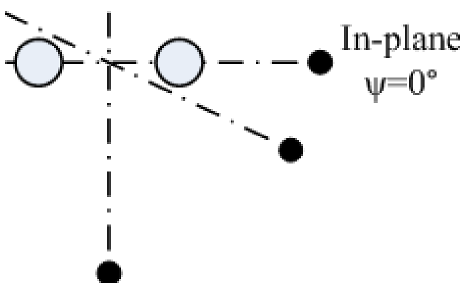

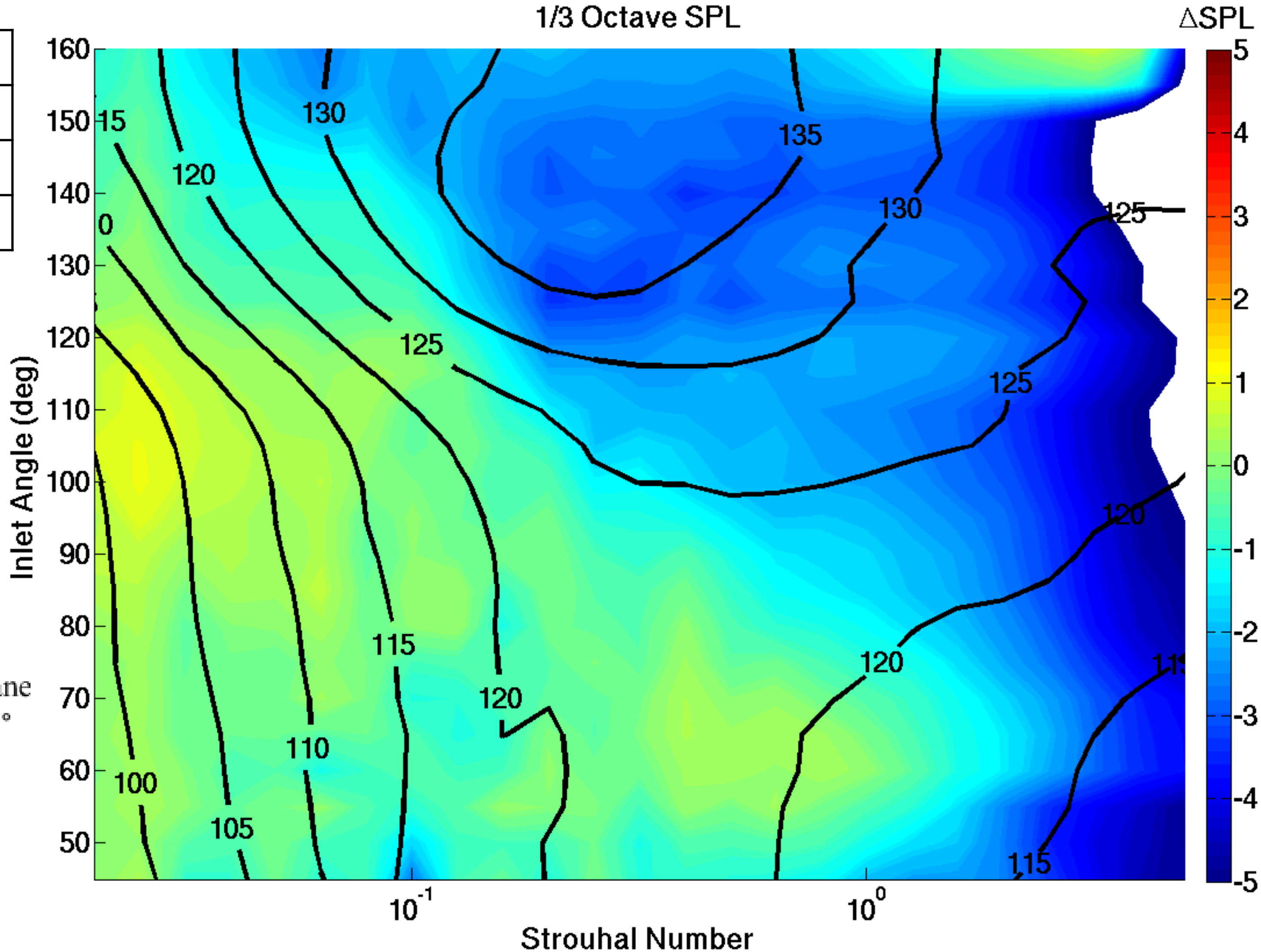

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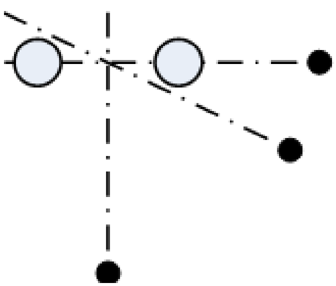

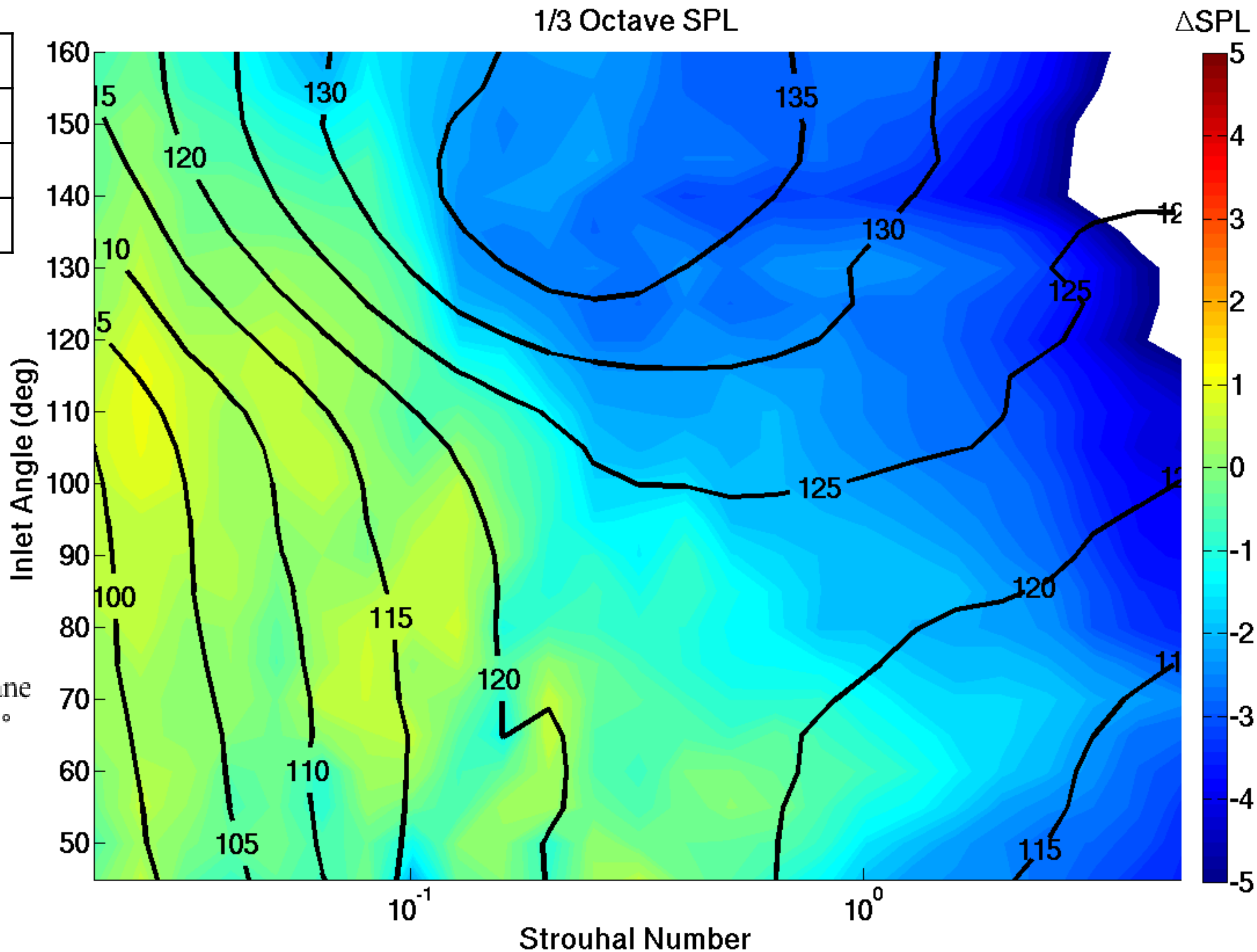

In-plane Measurements – Effect of Forward Flight

NPR	NTR	M_{fj}
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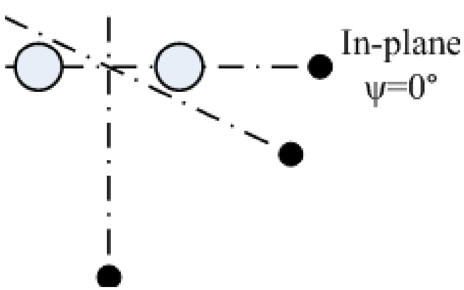

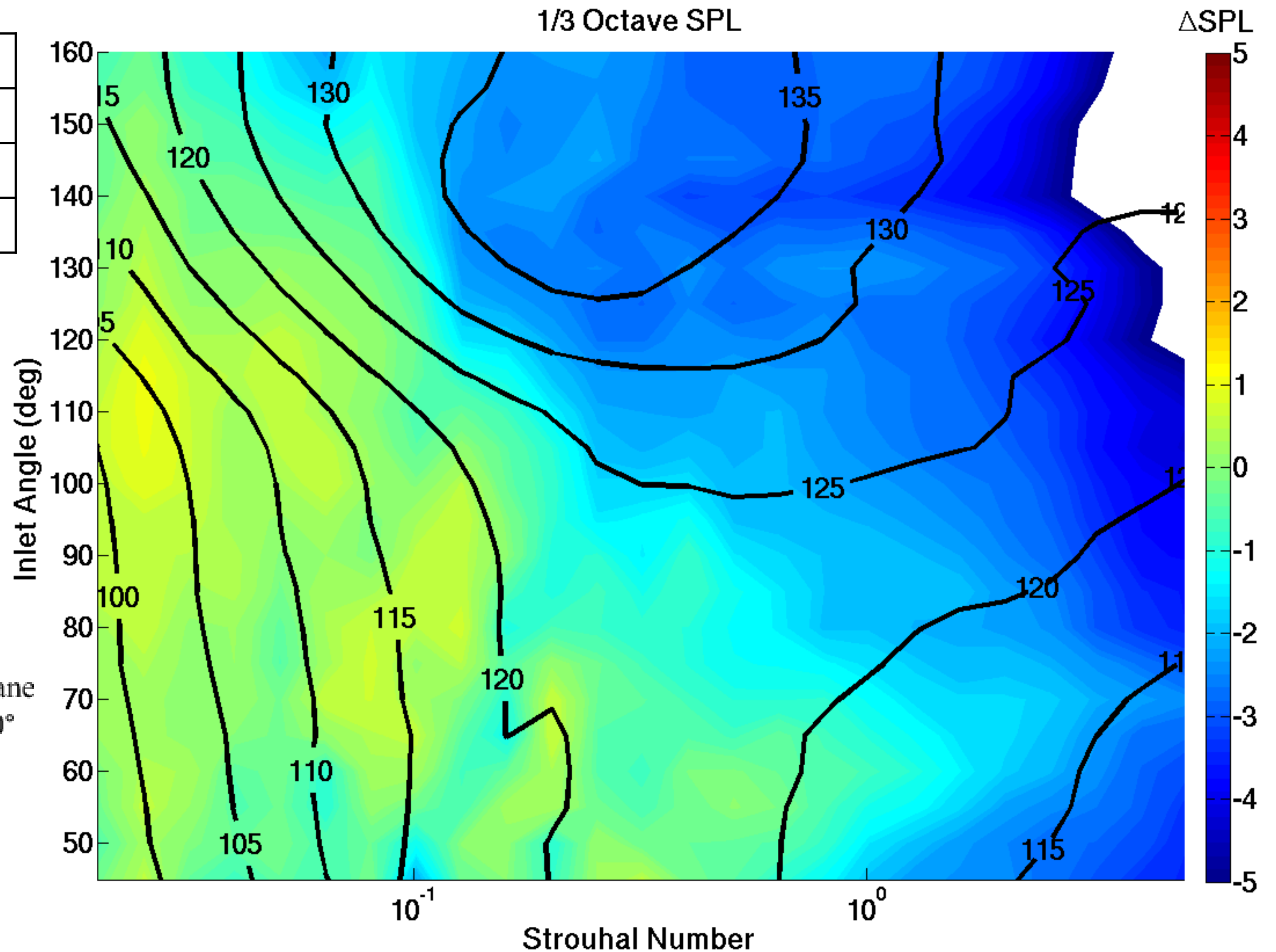

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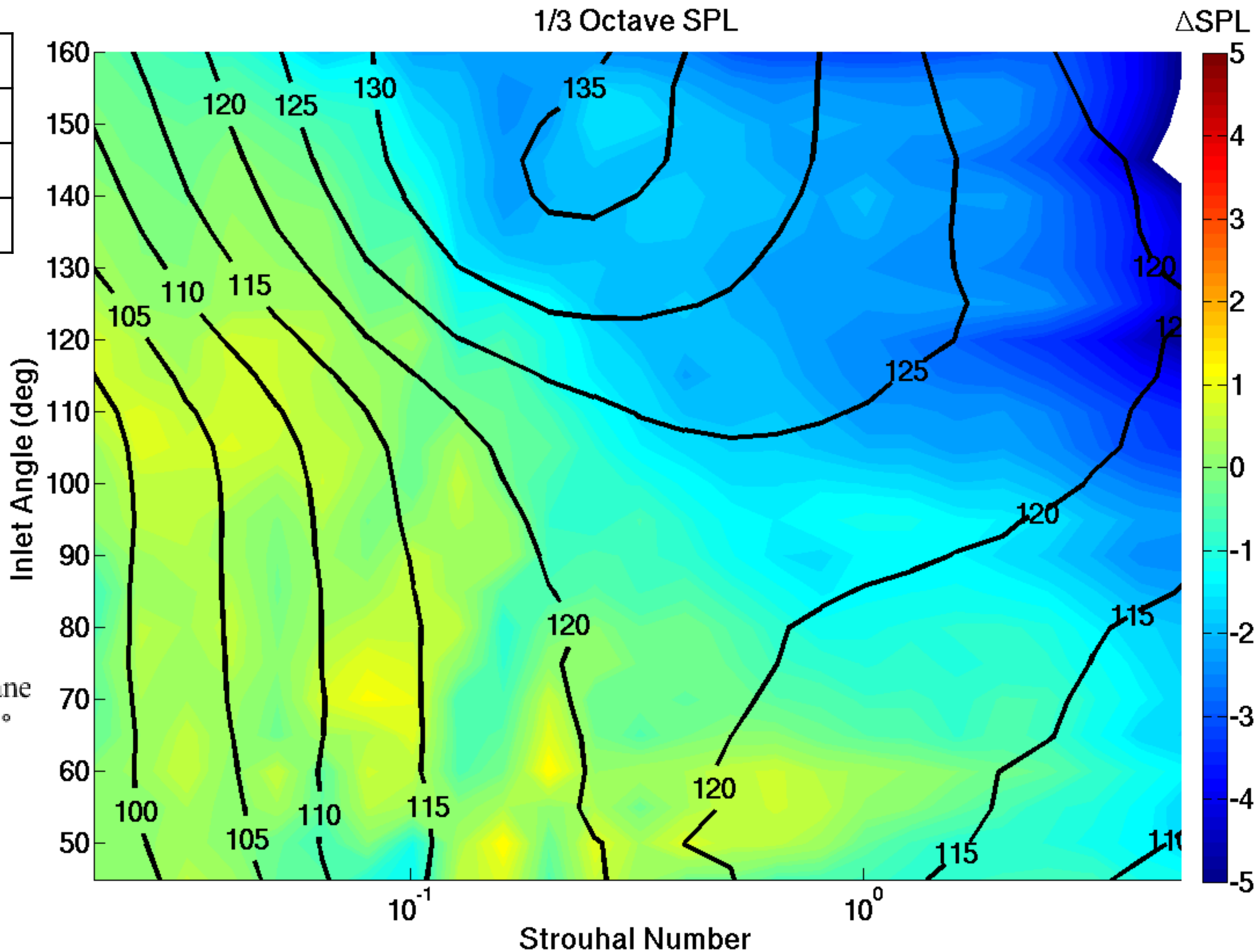

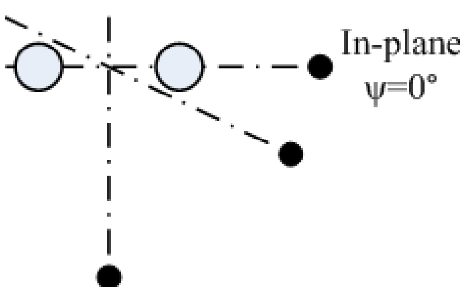

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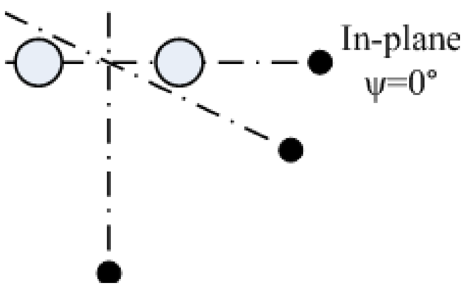

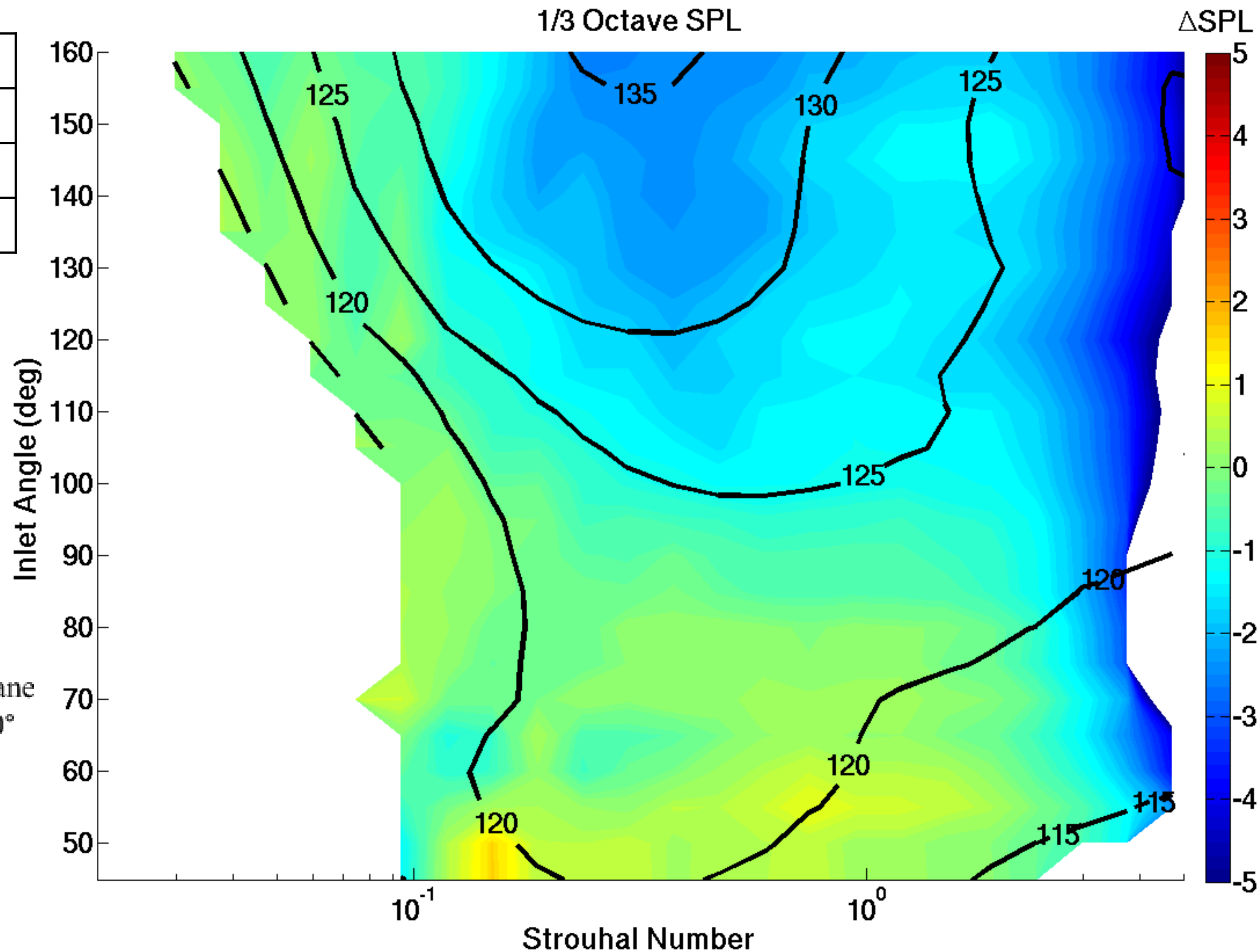

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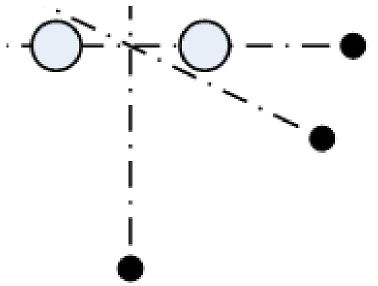

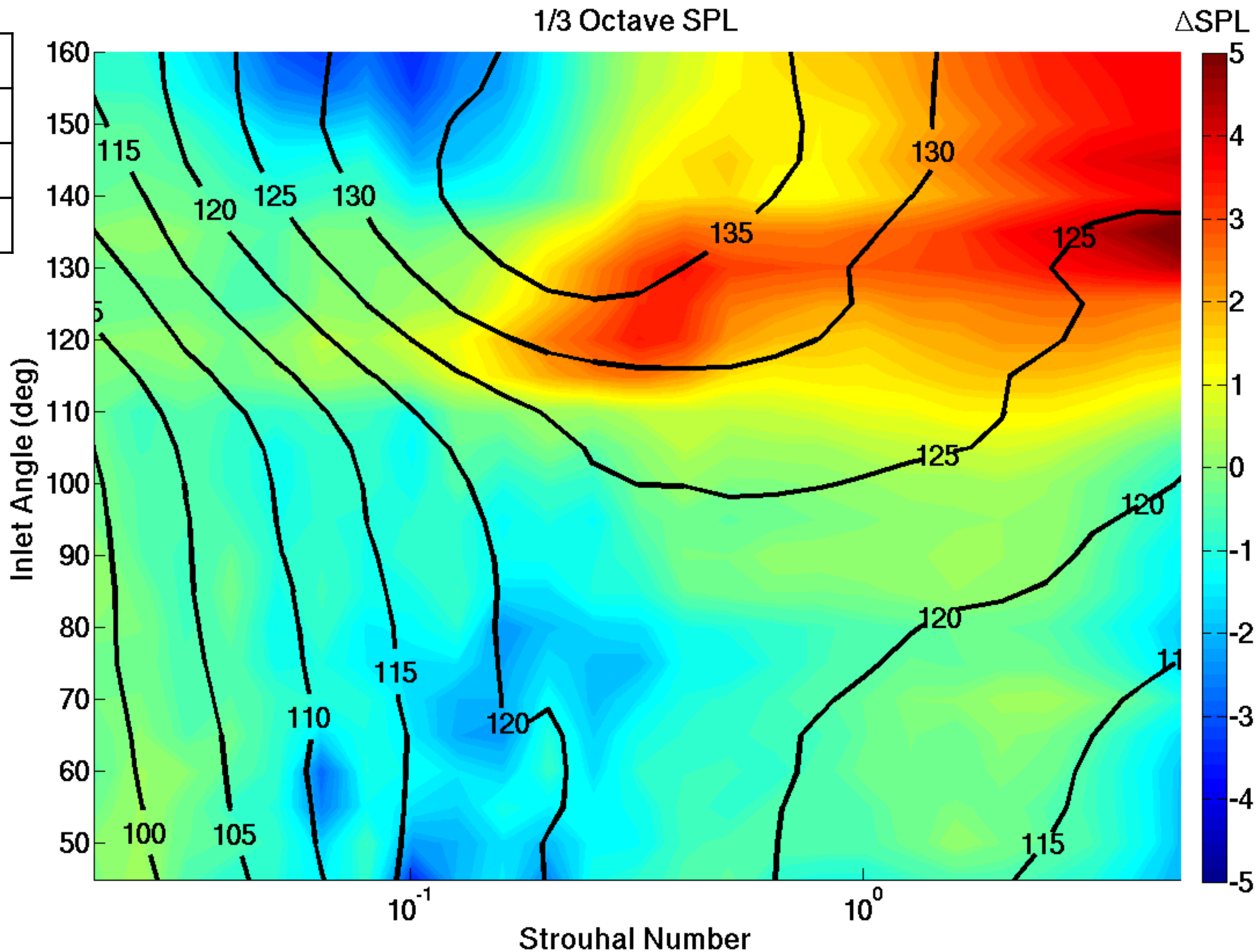

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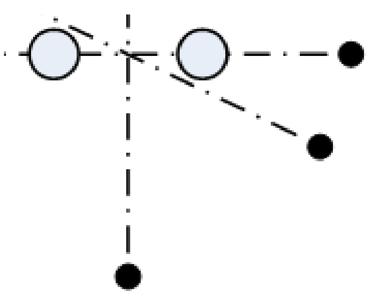
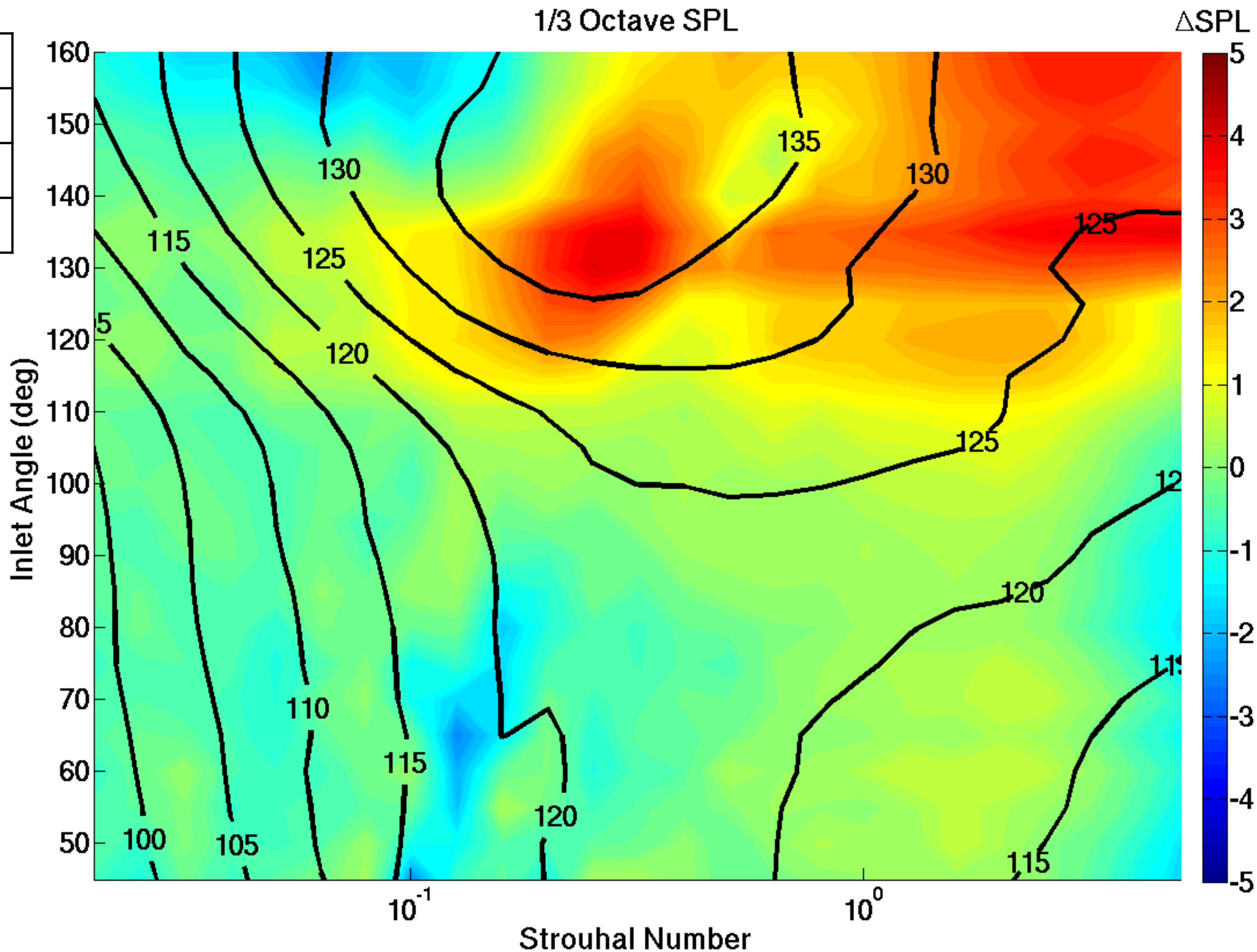


Out-of-plane
ψ=90°



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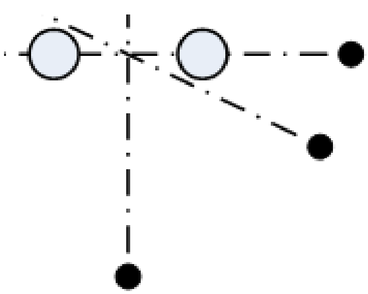

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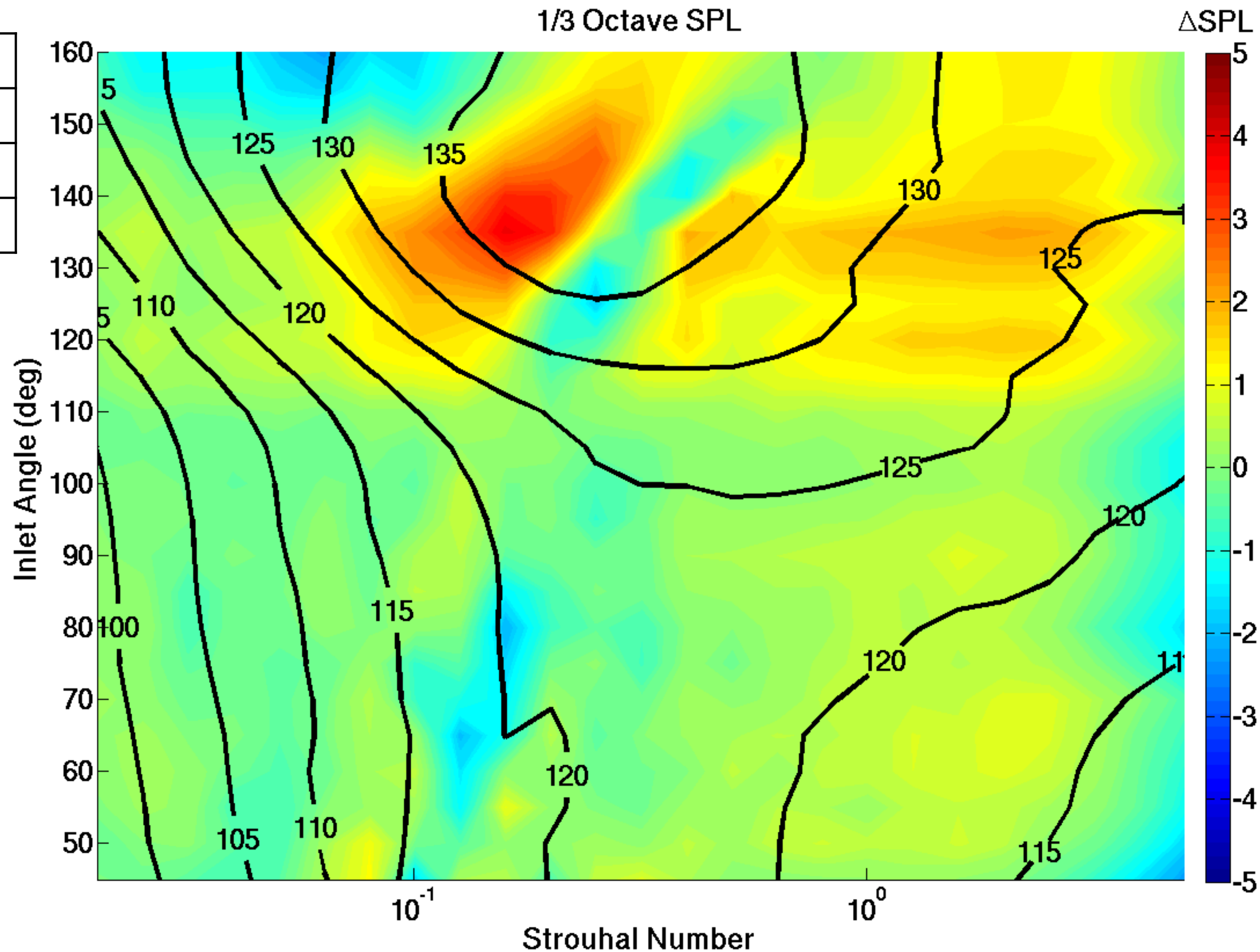

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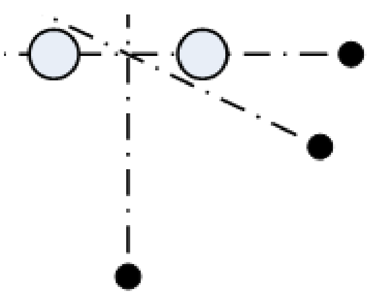

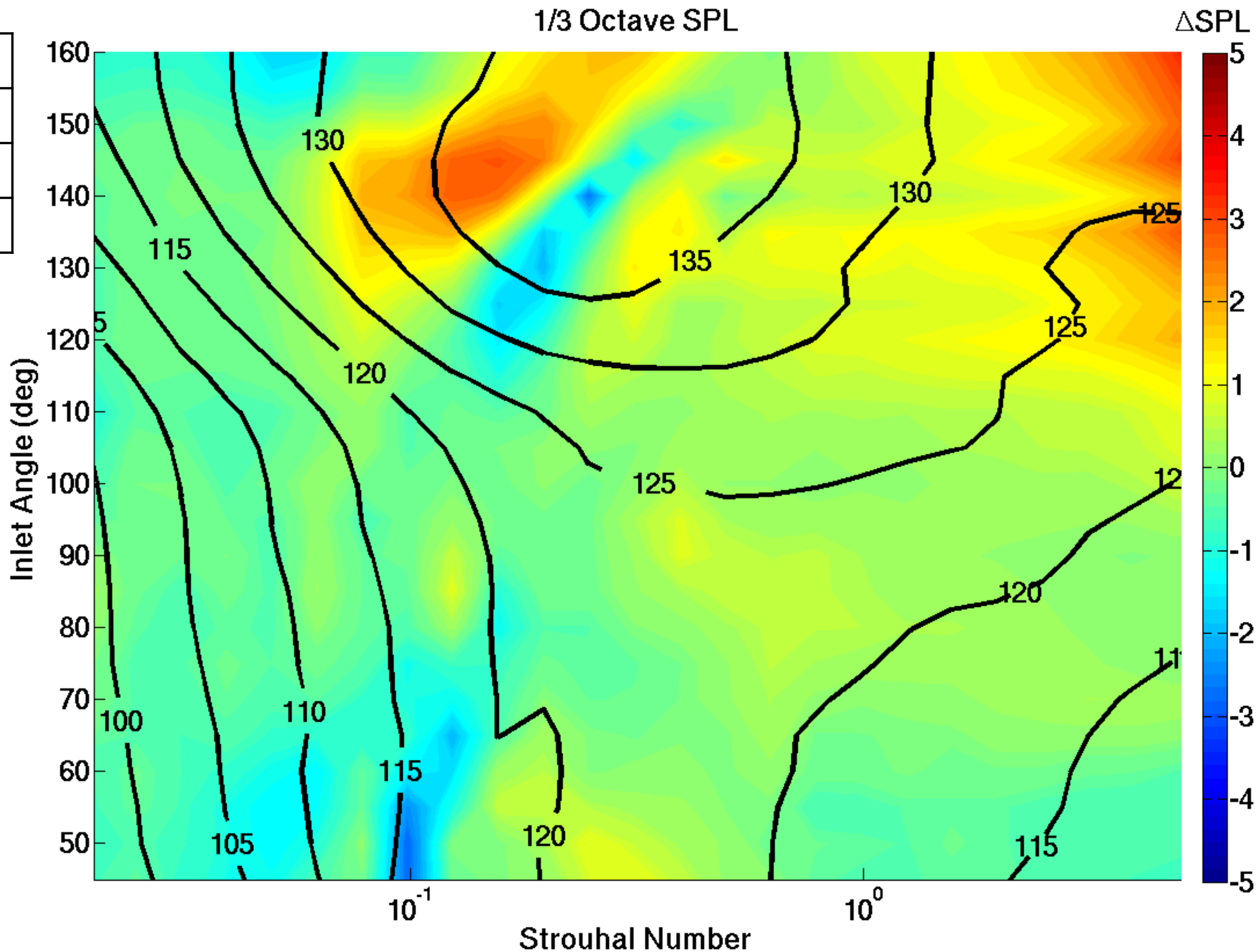

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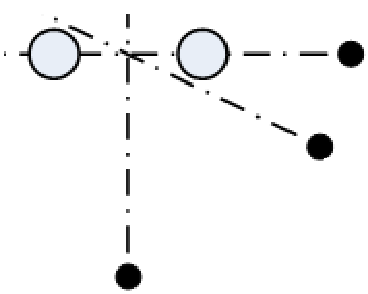

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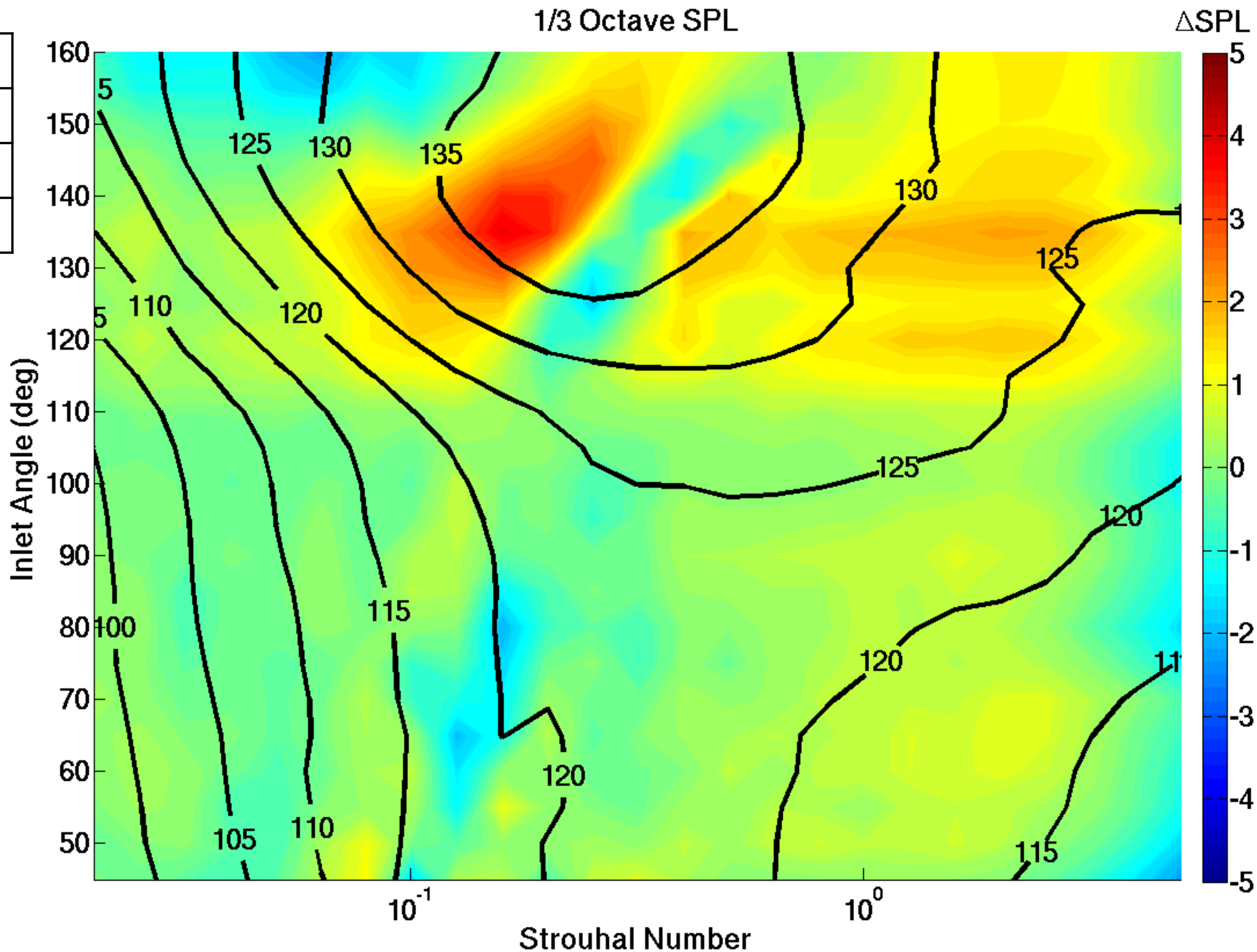

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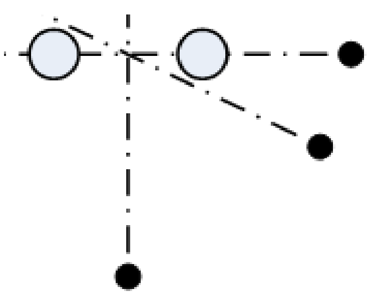

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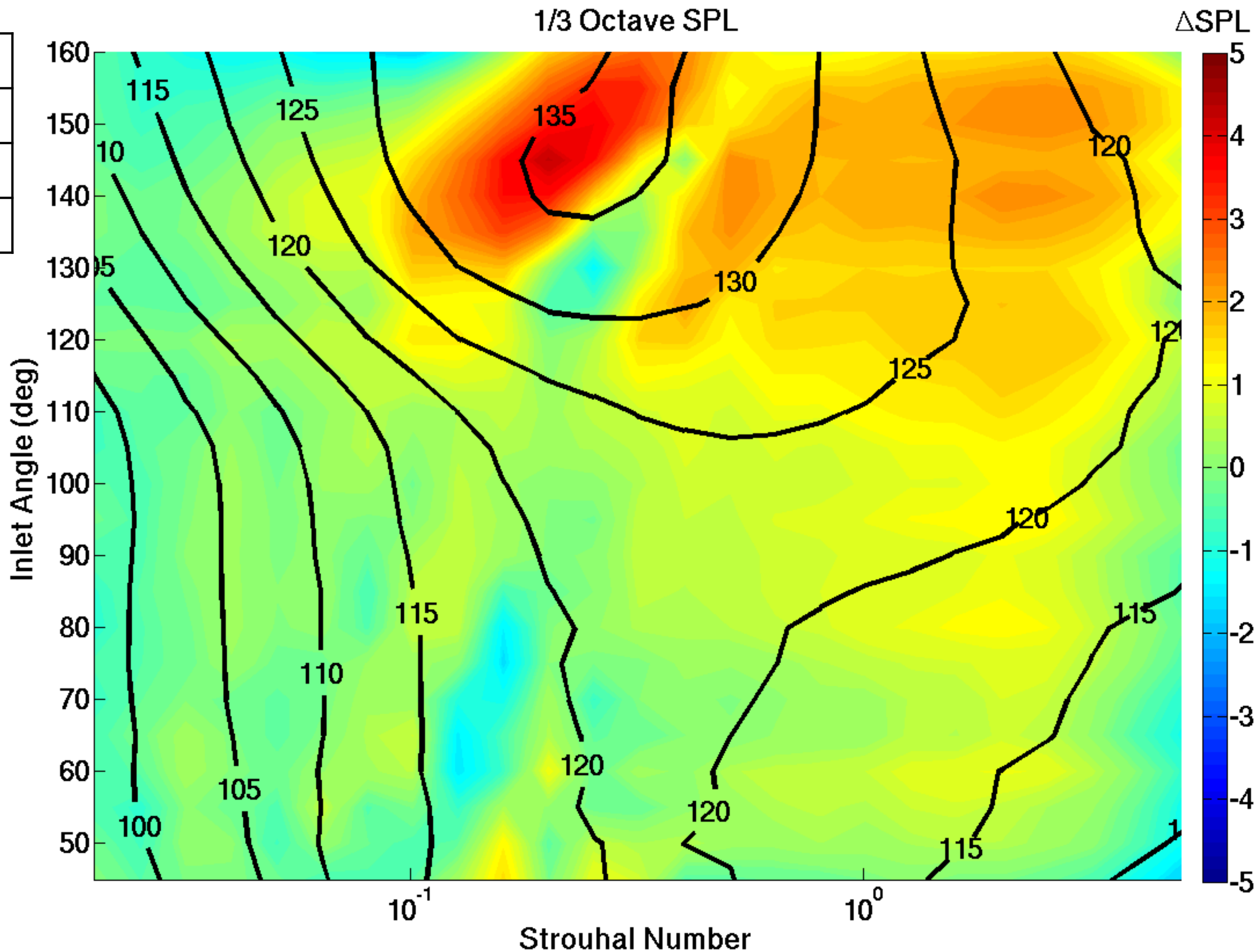

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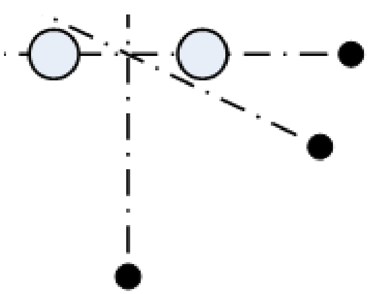

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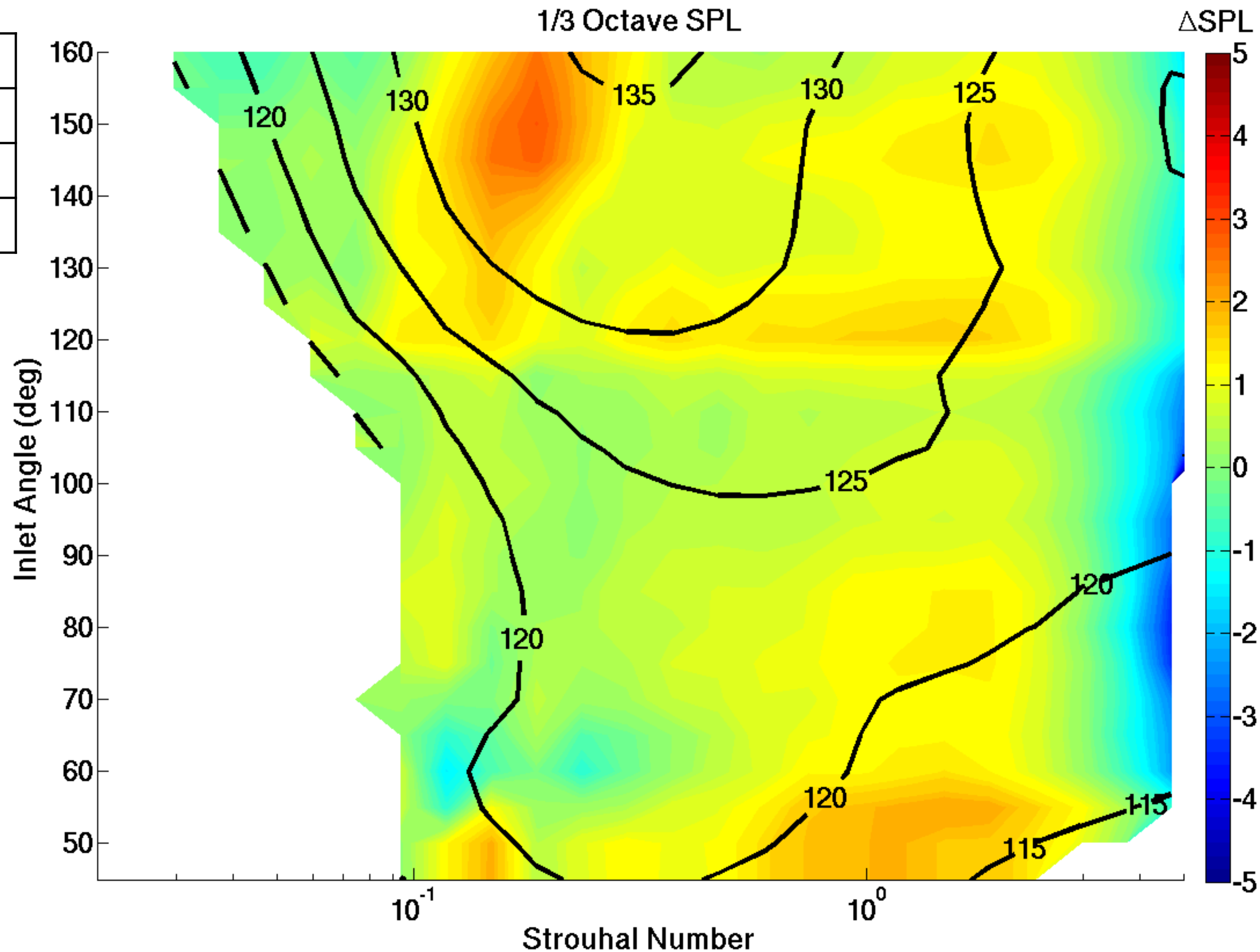
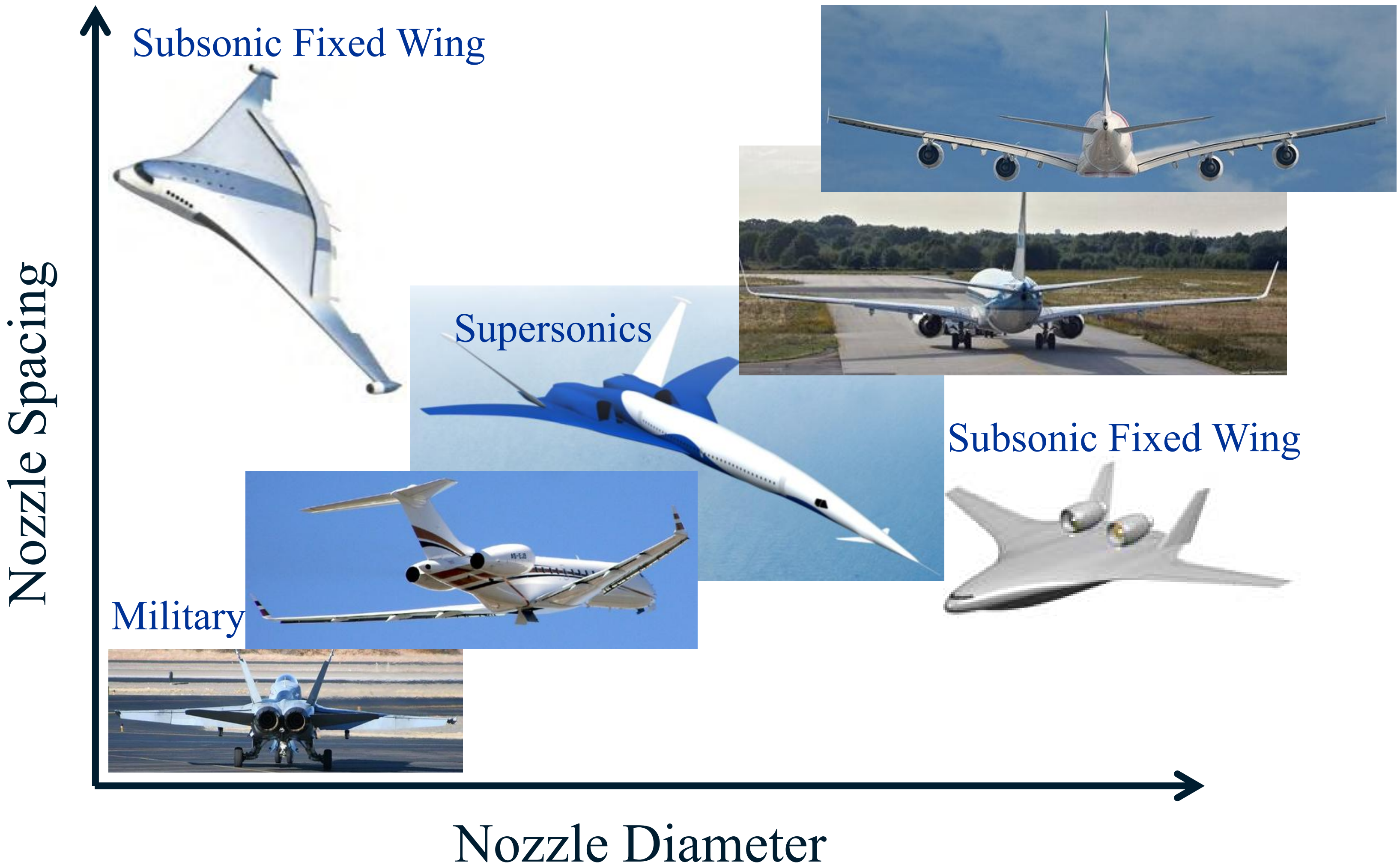


Twin Jet Sizing



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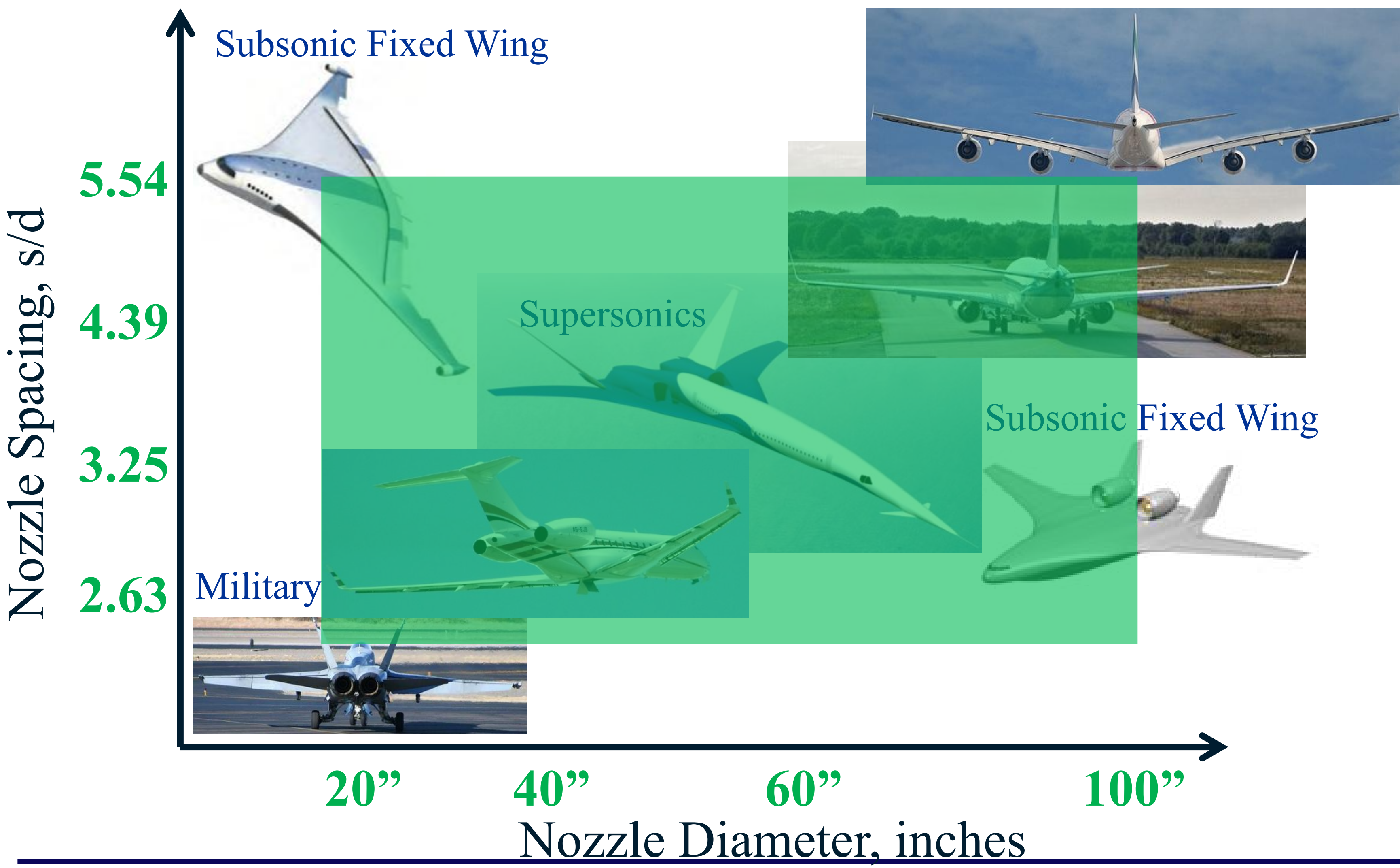

EPNL Calculations

- 1 foot lossless data were propagated at standard day to a 1775 foot linear array (approximate lateral microphone distance)
- Constant velocity (M=0.3), constant height flyover
- Full-scale nozzle diameters of 20”, 40”, 60” and 100”
- Repeatability of ±0.3 EPNdB
  - 95% confidence interval on a single condition and configuration that was repeated 3 times

$$EPNL = PNL_{max} + \text{Duration Factor} + \text{Tone Correction Factor}$$

$$\Delta EPNL = EPNL_{twin} - EPNL_{single+3EPNdB}$$

Twin Jet EPNL Corrections

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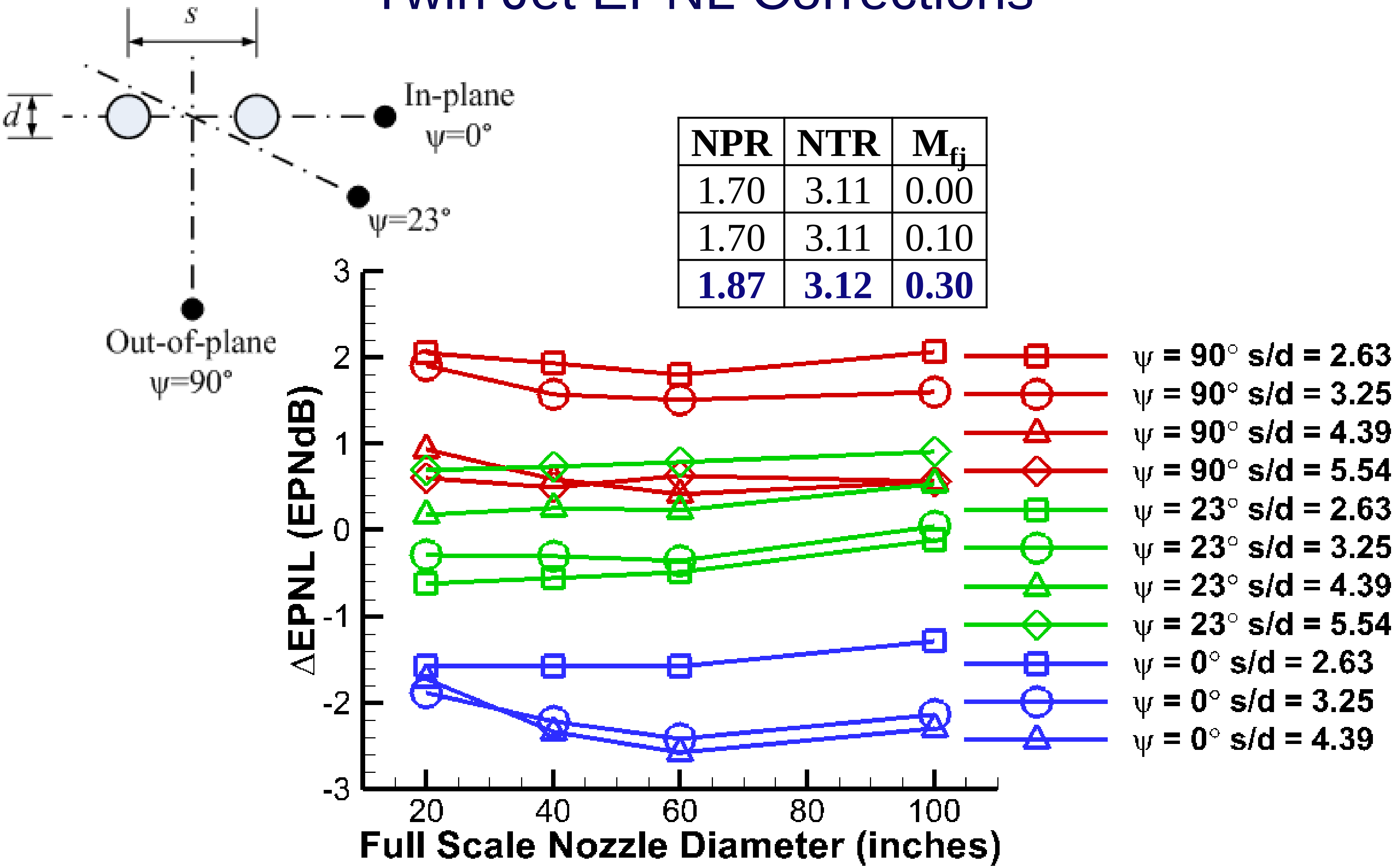
1.87	**3.12**	**0.30**



Conclusions

- Coherent interactions between the jets can increase the peak out-of-plane jet noise 3 dB over a single jet plus 3dB, but these interactions are weakened with forward flight
- Full scale nozzle diameter did not have a significant effect on twin jet EPNL calculations
- Twin jet effects can account for up to a 5 EPNdB difference between in-plane and out-of-plane measurements
- For a horizontal twin jet configuration, the single jet plus 3 EPNdB estimation would be sufficient for the lateral microphone at any of the jet spacings tested