Making sense of "north-south asymmetry"

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Terminology

- "Power asymmetry"

  - The power spectrum measured from one direction in the sky is different from that measured from the opposite direction.

- "Dipole modulation"

  - The observed temperature field is modulated by a dipolar function, $T(n) \rightarrow T(n)[1+A\ n\cdot p]$, where p is some preferred direction.

Be aware:

- A power asymmetry can result from a dipole modulation, but a dipole modulation is not the only explanation for a power asymmetry!

- A dipole modulation gives a powerful constraint on the magnitude of a power asymmetry, *assuming that a dipole modulation is the correct phenomenology*.
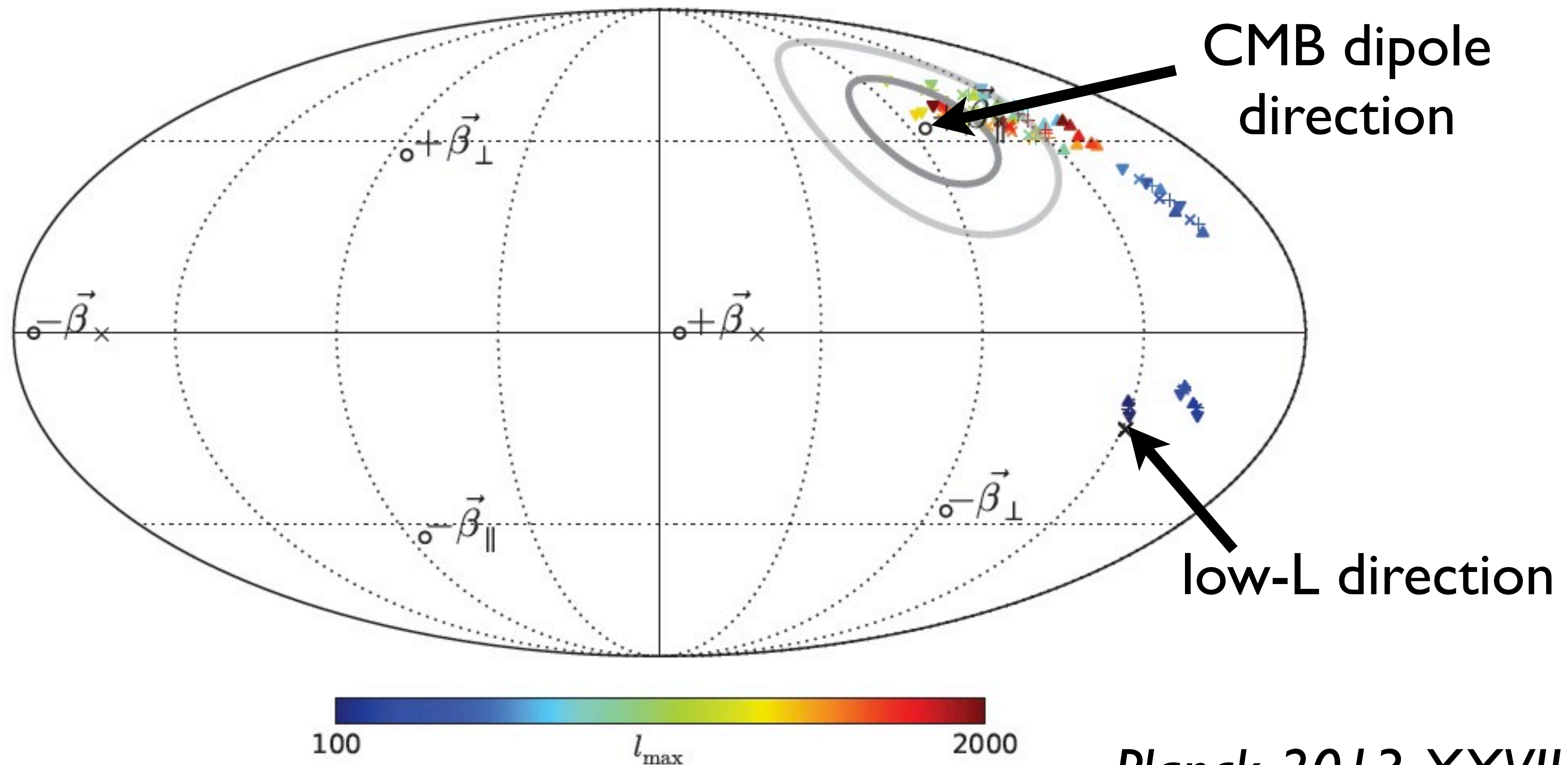
  - However, that's not the only possibility.

Phenomenology [low-L]

- Power asymmetry is seen (at ~2–3σ) at low multipoles, e.g., l<100

- Dipole modulation is also seen (at ~2–3σ) at low multipoles, e.g., l<100, with A~0.07 (7% modulation)

- The low-multipole asymmetry/modulation points toward the same location in the sky

Phenomenology [high-L]

- Dipole modulation is seen (at ~4σ) at high multipoles, e.g., 500<l<2000, with A~0.003 (0.3% modulation)

- The direction points toward the CMB dipole direction.

- This is the expected result: A = 2.5*(v/c) ~ 0.003

Changes in the modulation directions as a function of l_{max}

CMB dipole direction

$+\vec{\beta}_{\perp}$

$-\vec{\beta}_{\times}$ $+\vec{\beta}_{\times}$

$-\vec{\beta}_{\perp}$

$-\vec{\beta}_{\parallel}$

low-L direction

100   l_{max} 2000

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Low-L modulation does not extend to higher multipoles
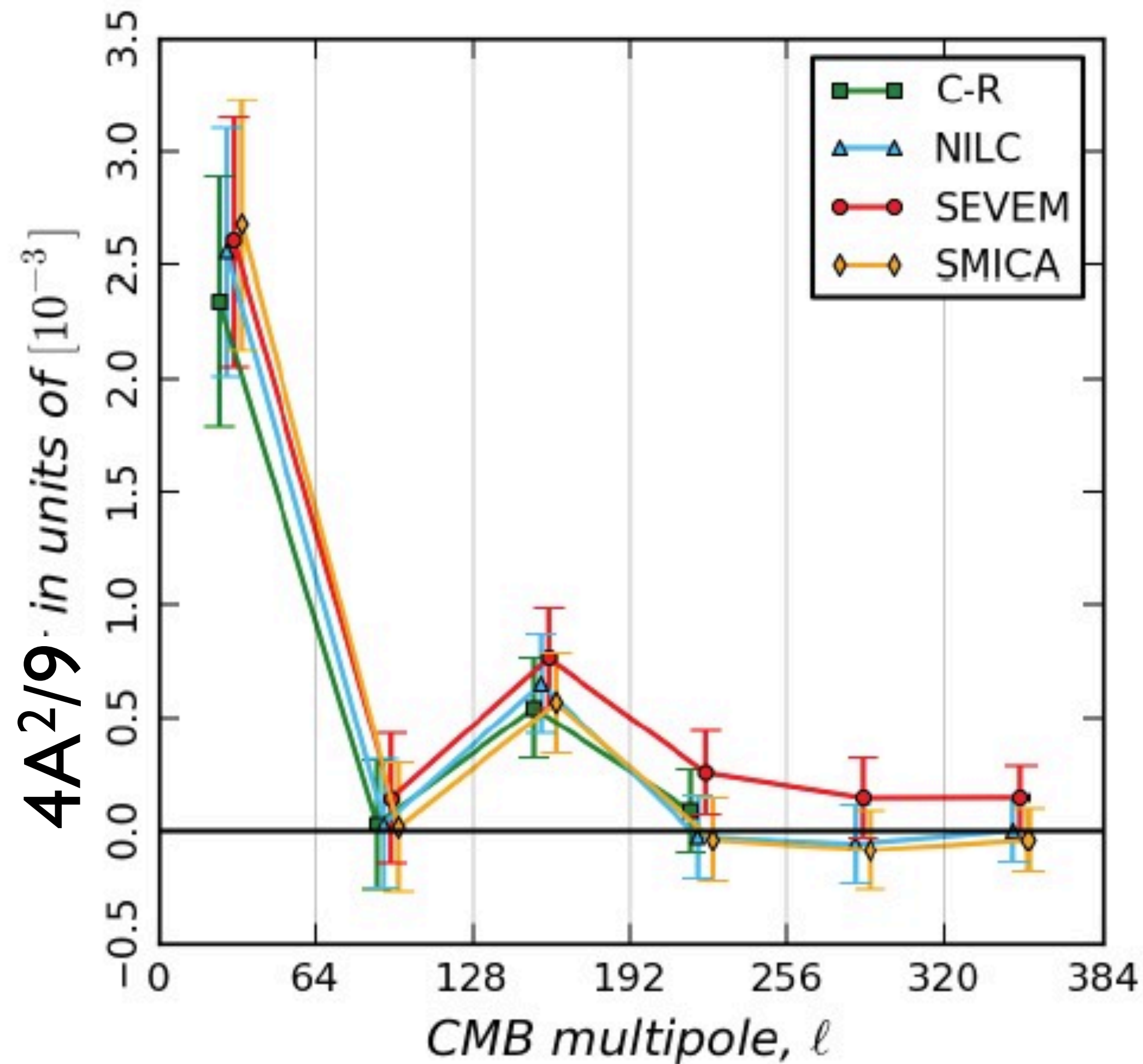
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Current status

- Dipole modulation:

  - A~0.07 at l<100 pointing toward (l,b)=(226,–17)

  - A~0.003 at l>100 pointing toward the CMB dipole

- Power asymmetry:

  - Seen at l<100

  - **How about l>100?**

Power asymmetry at high L?

with respect to
(l,b)=(225,1)
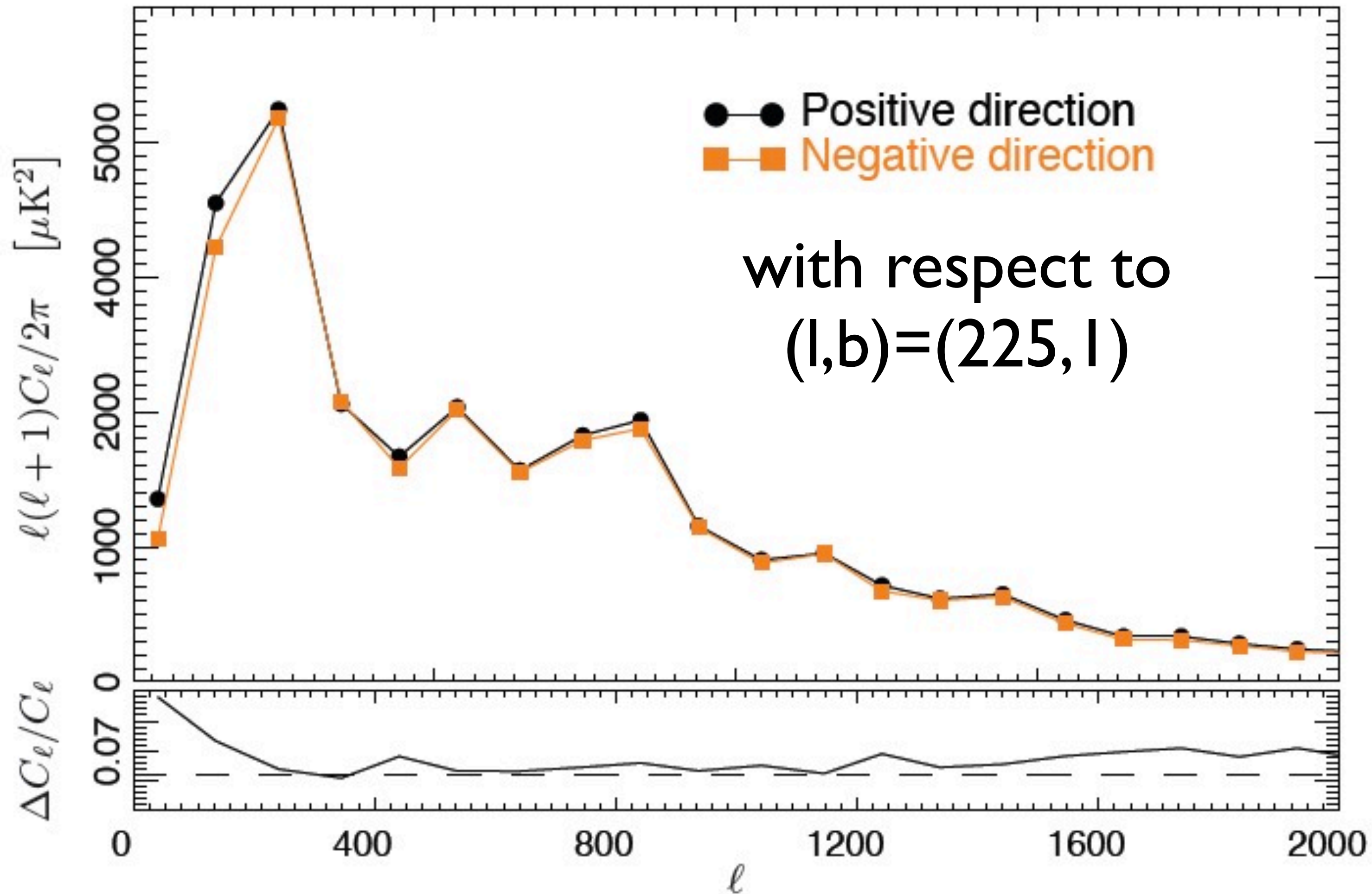
- But, this appears to be inconsistent with the dipole modulation constraints from higher multipoles!
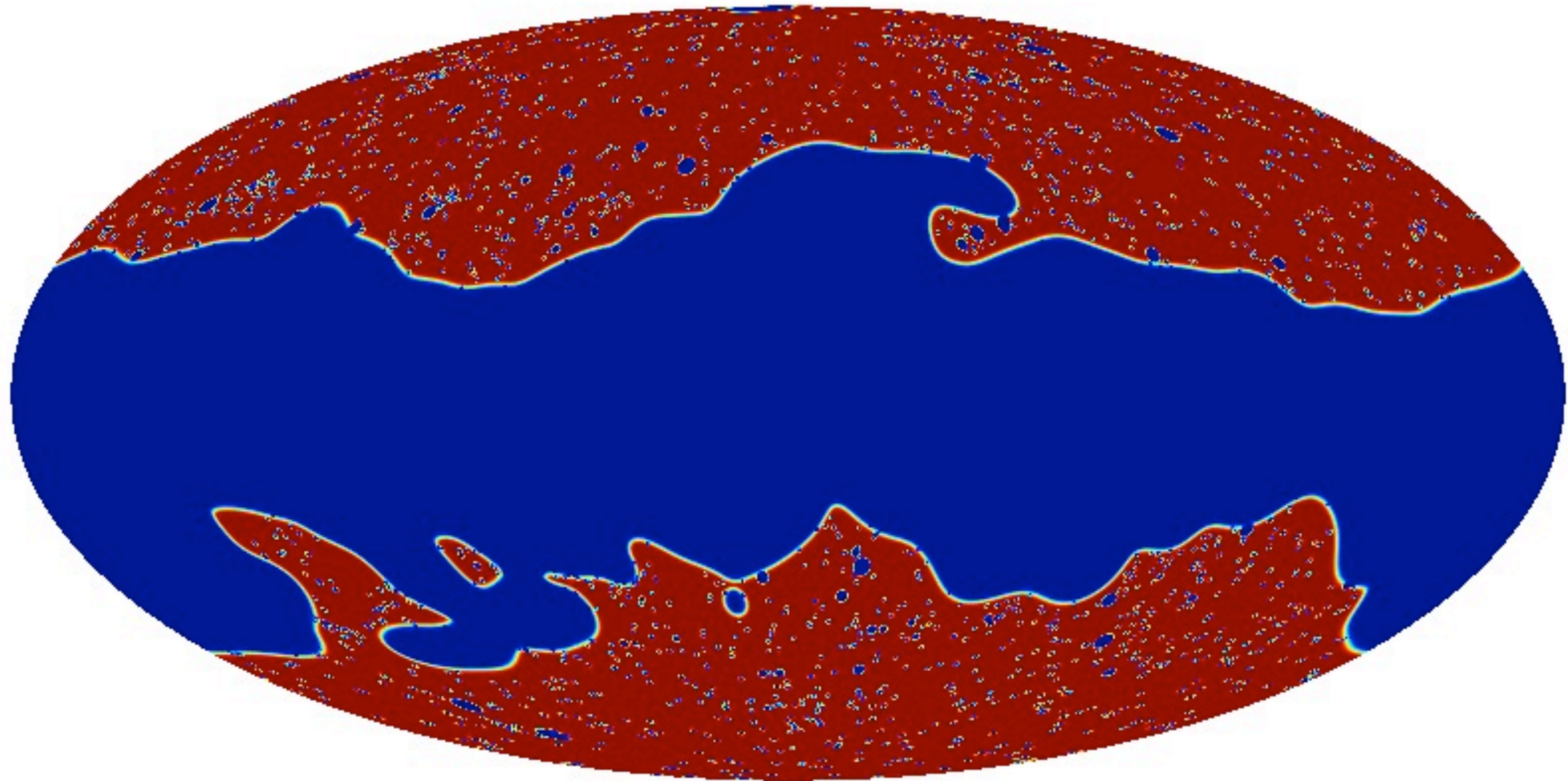
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Galactic mask used by this analysis

CS_SMICA89

0.00   +1.00
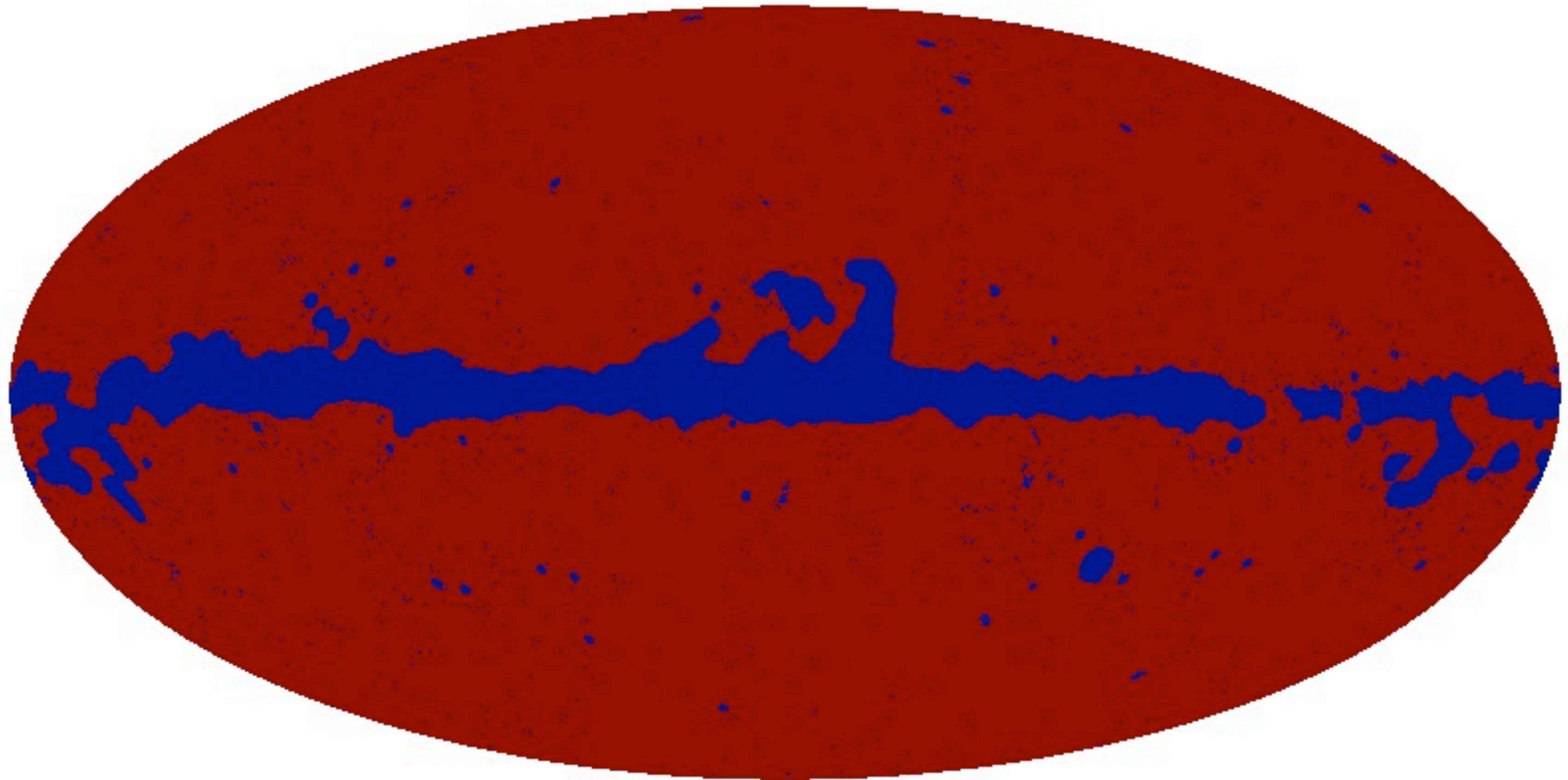
Galactic mask used for cosmology

CL39

0.00 ▬▬▬▬▬▬▬▬▬▬ +1.00
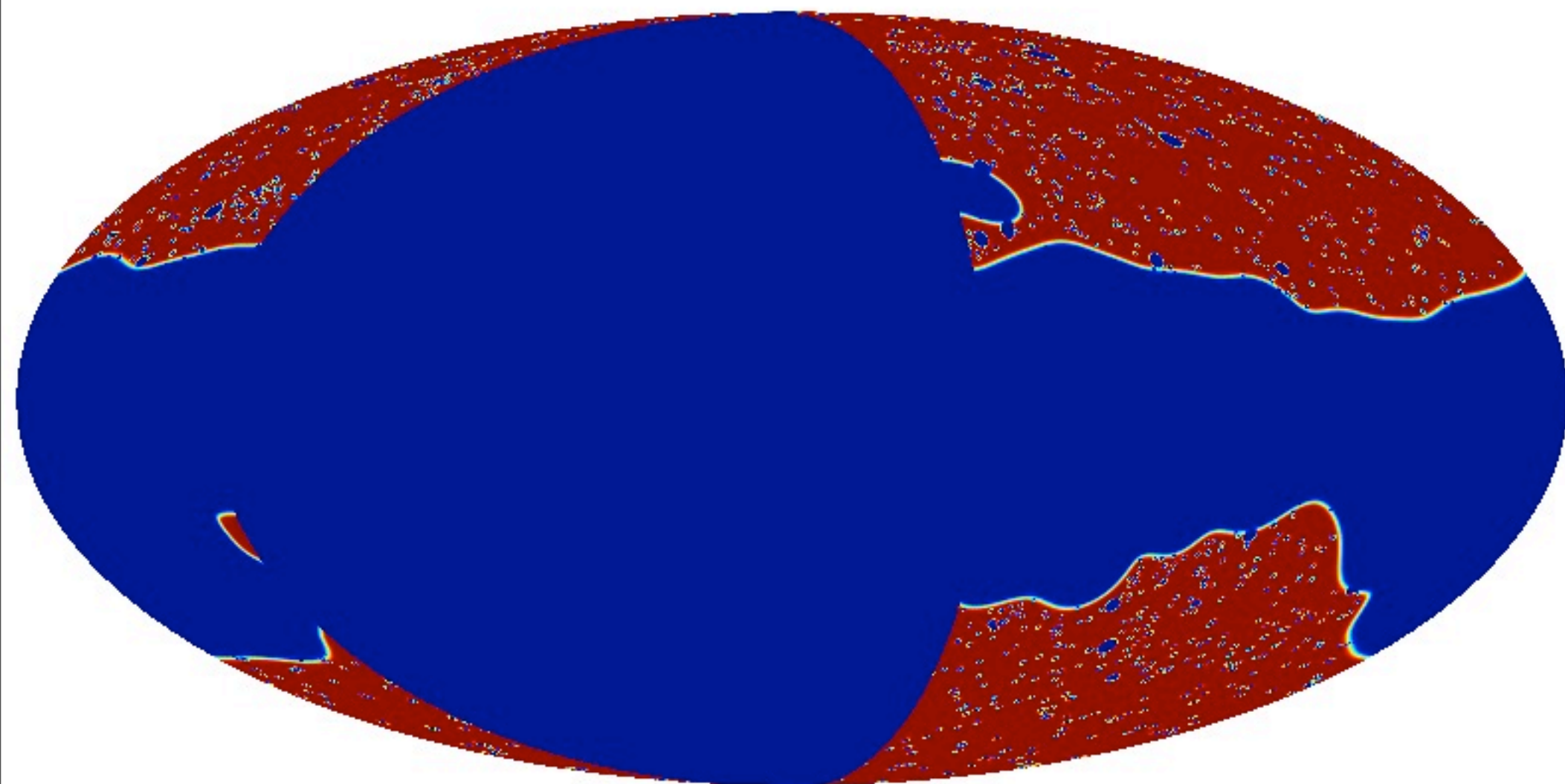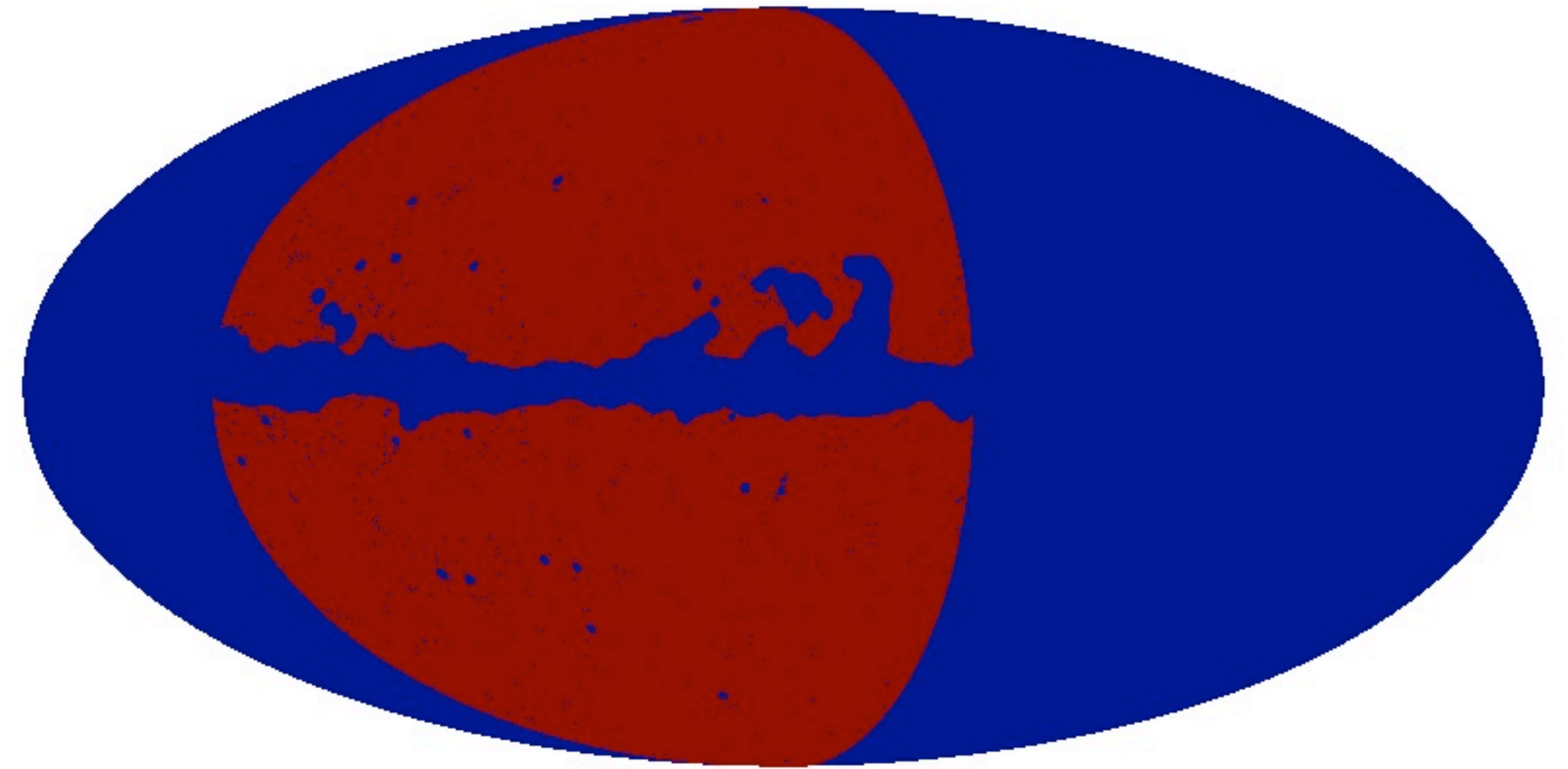
Hemispherical masks

north_1225_b1_cs_smica89

south_1225_b1_cs_smica89
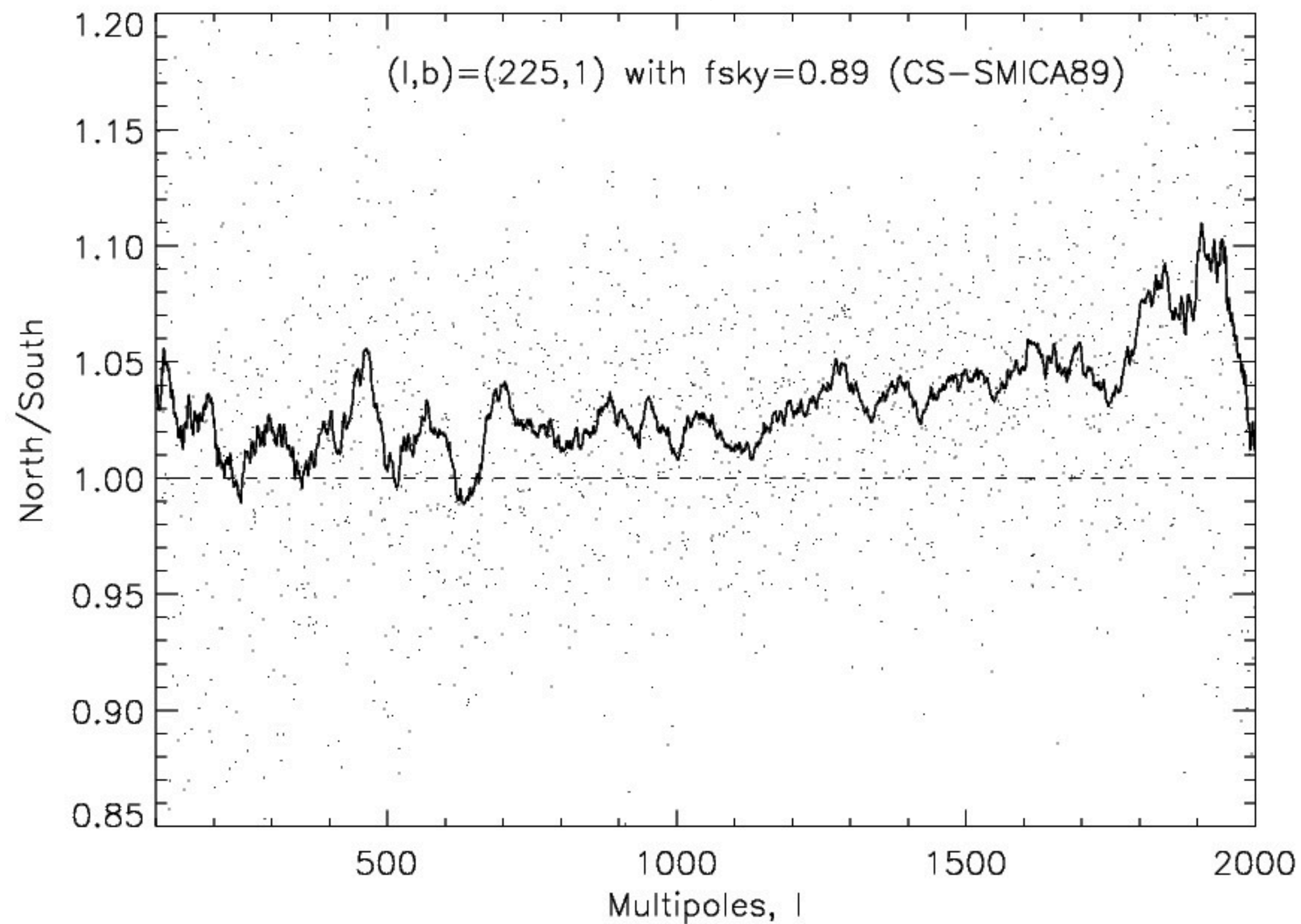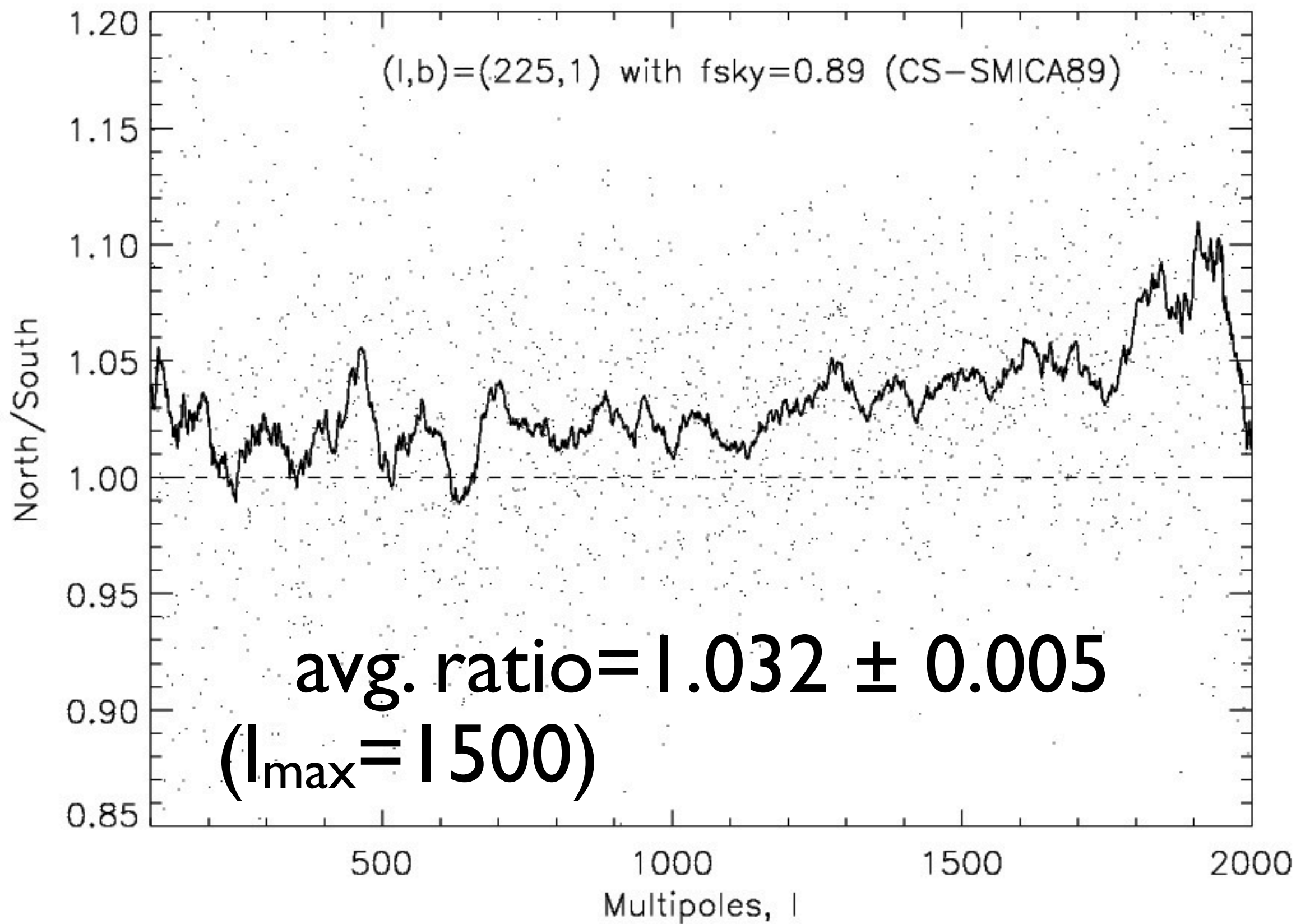
0.00 +1.00

0.00 +1.00
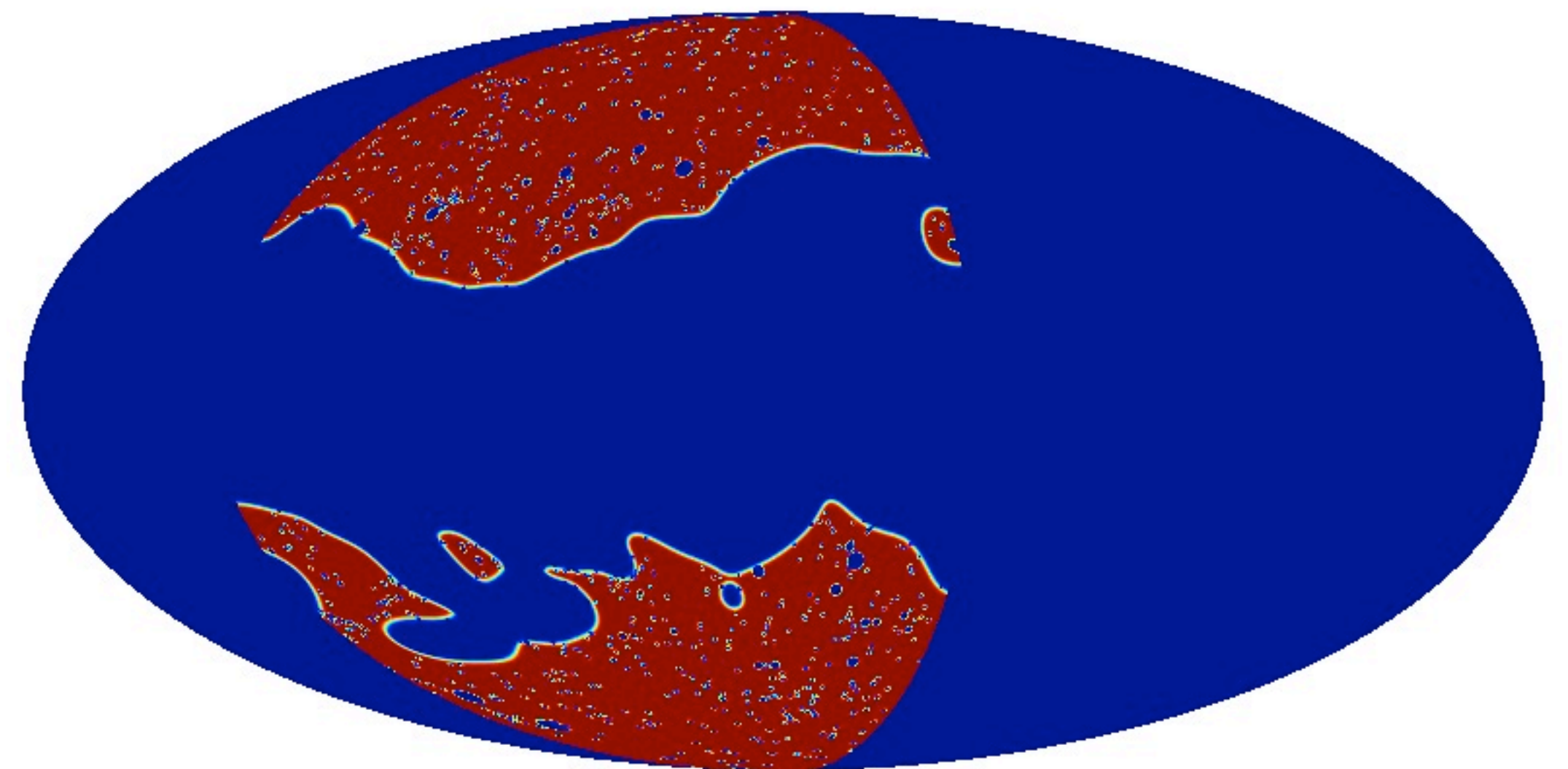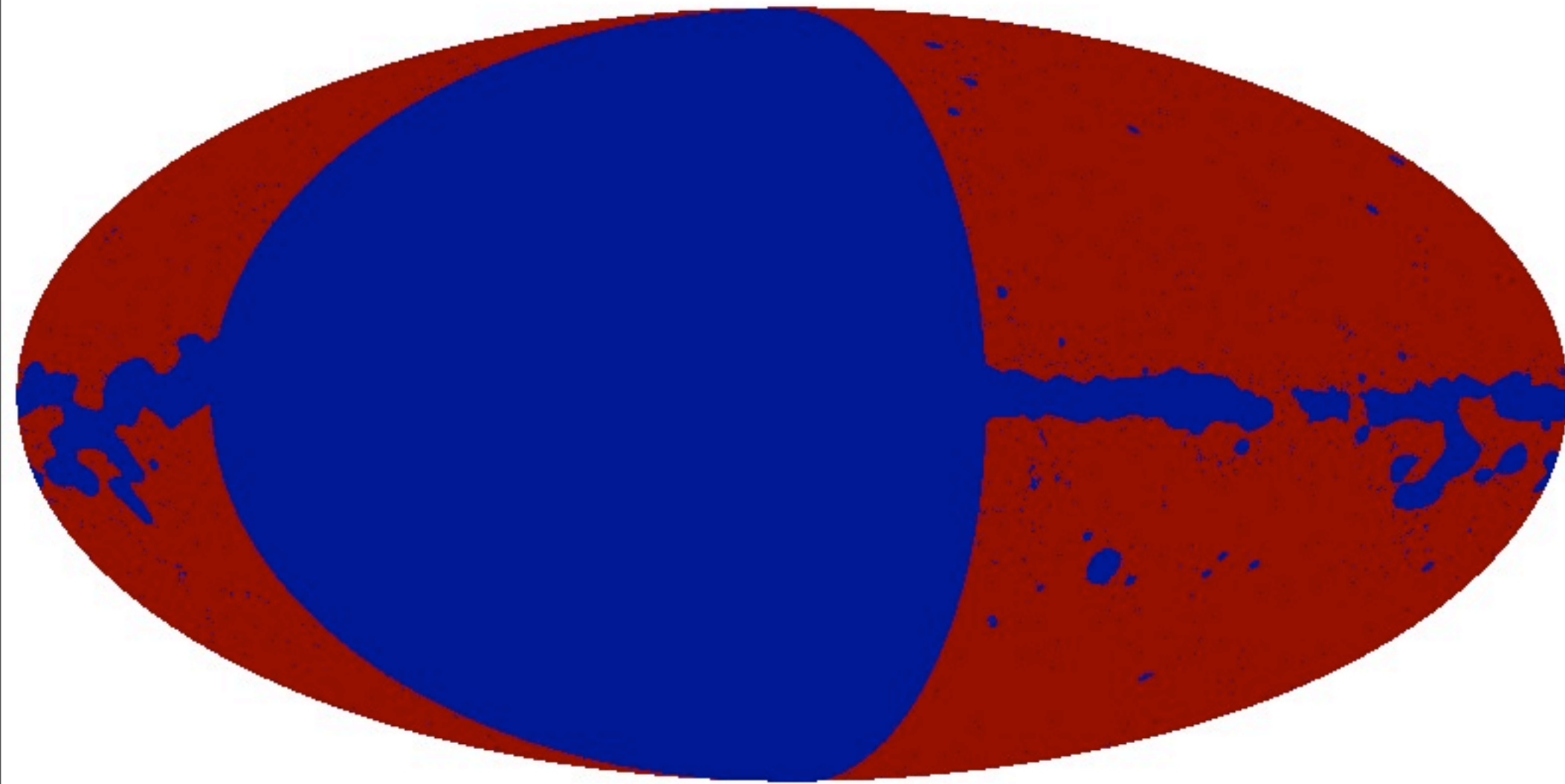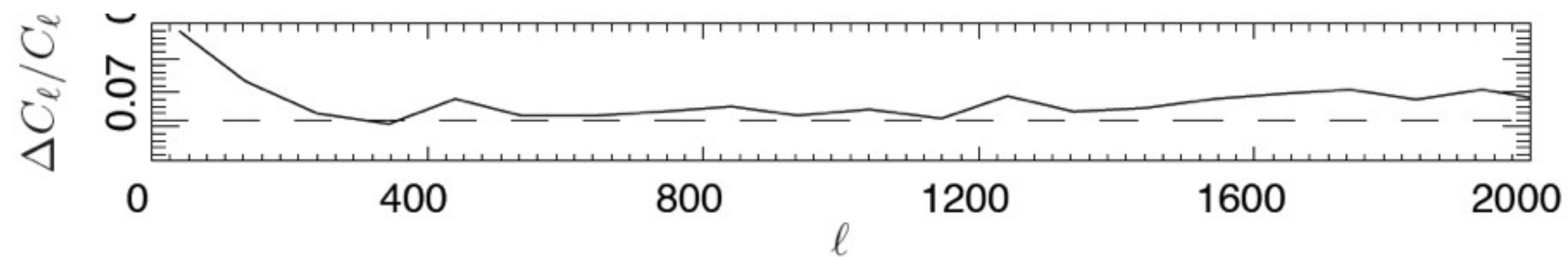
Aggressive Mask

Planck team

Agreement?

My analysis

Changing Mask

aggressive

(l,b)=(225,1) with fsky=0.89 (CS−SMICA89)

avg. ratio=1.032 ± 0.005
(l_{max}=1500)

cosmology

(l,b)=(225,1) with fsky=0.39 (CL39)

avg. ratio=1.020 ± 0.006
(l_{max}=1500)

North/South

Multipoles, l
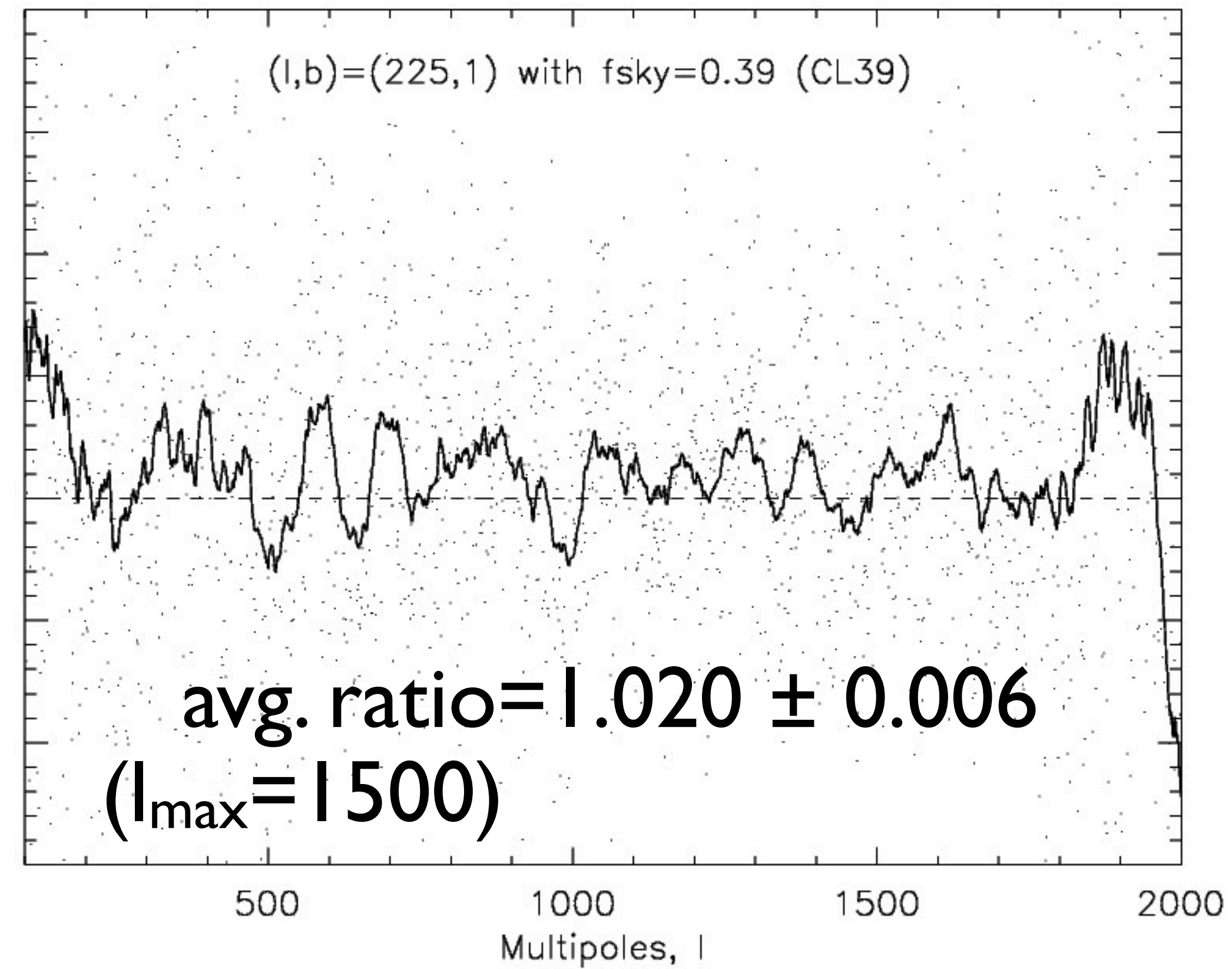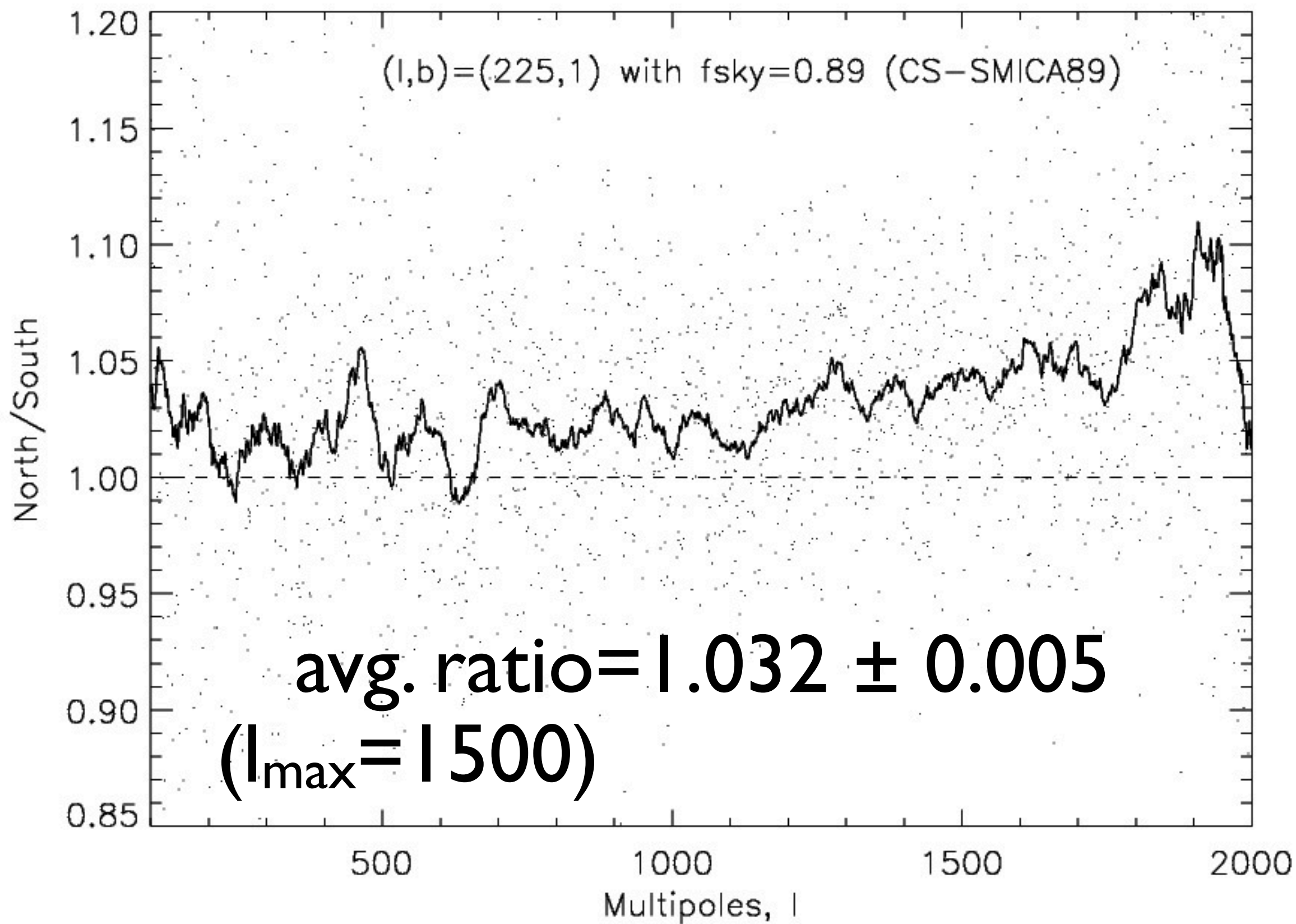
Galactic mask used for NG/Doppler

union73

0.00   +1.00
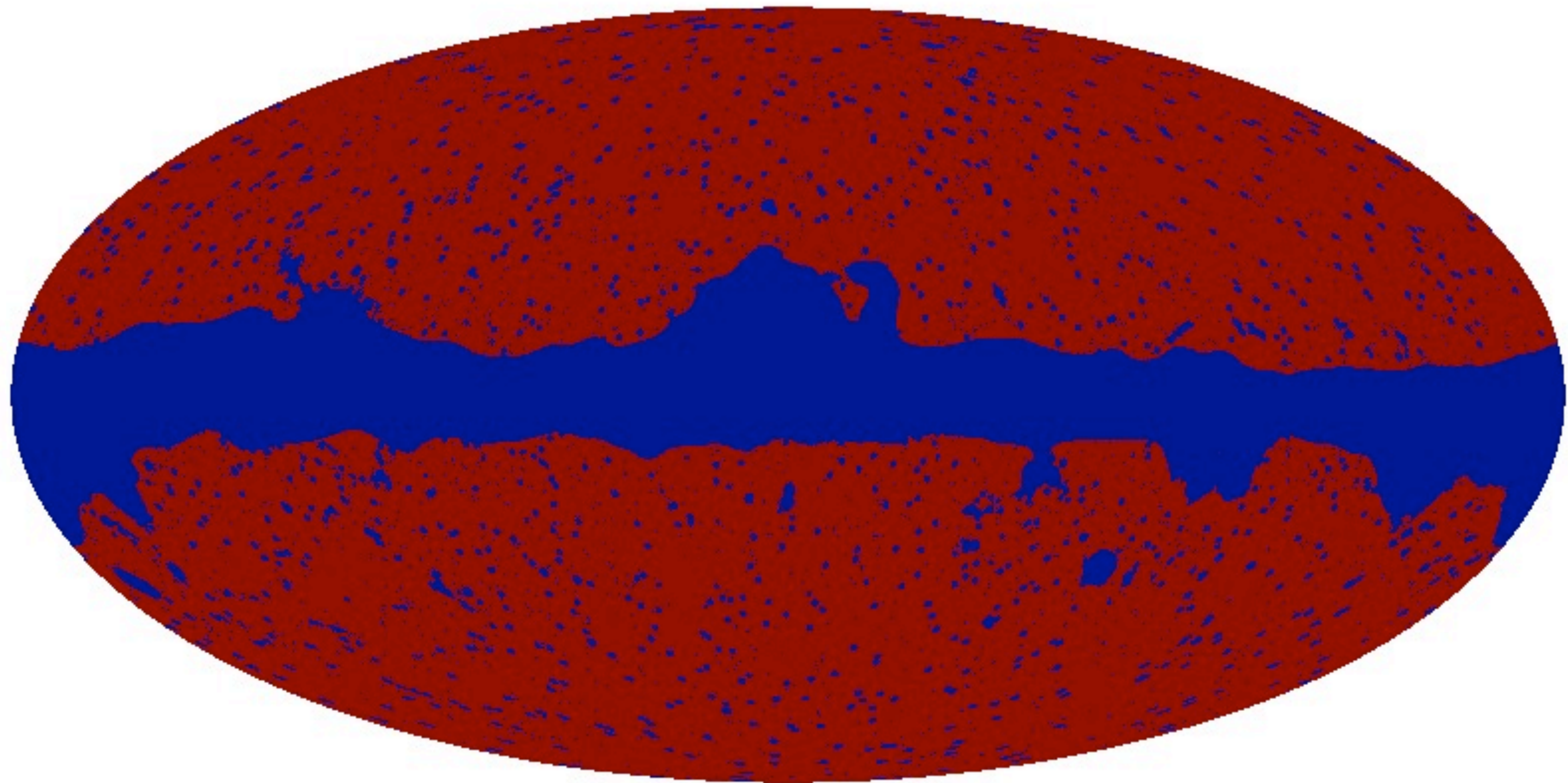
Changing Mask

aggressive

NG/doppler

(l,b)=(225,1) with fsky=0.89 (CS−SMICA89)

(l,b)=(225,1) with fsky=0.73 (Union73)

avg. ratio=1.032 ± 0.005 (l_{max}=1500)

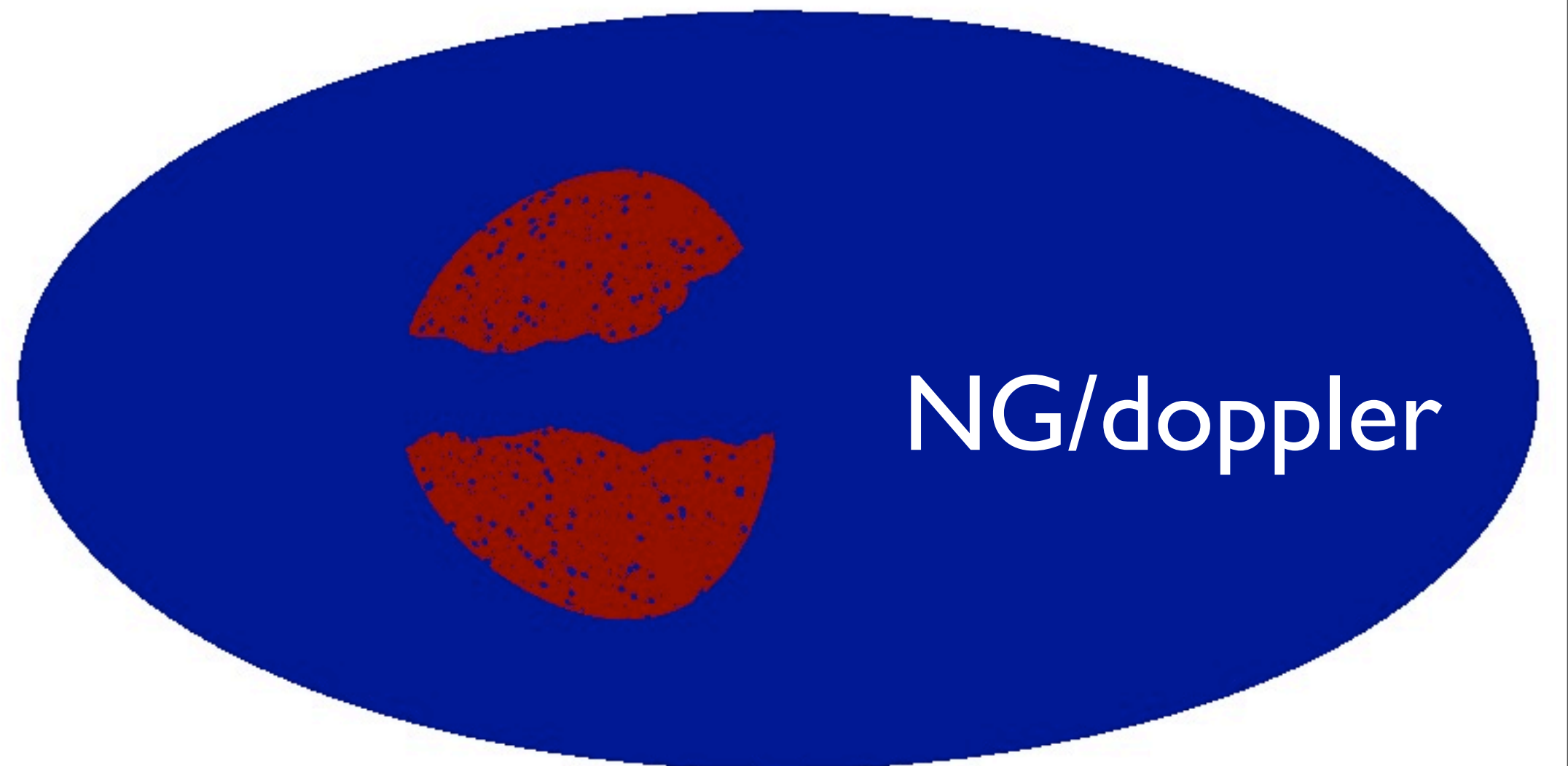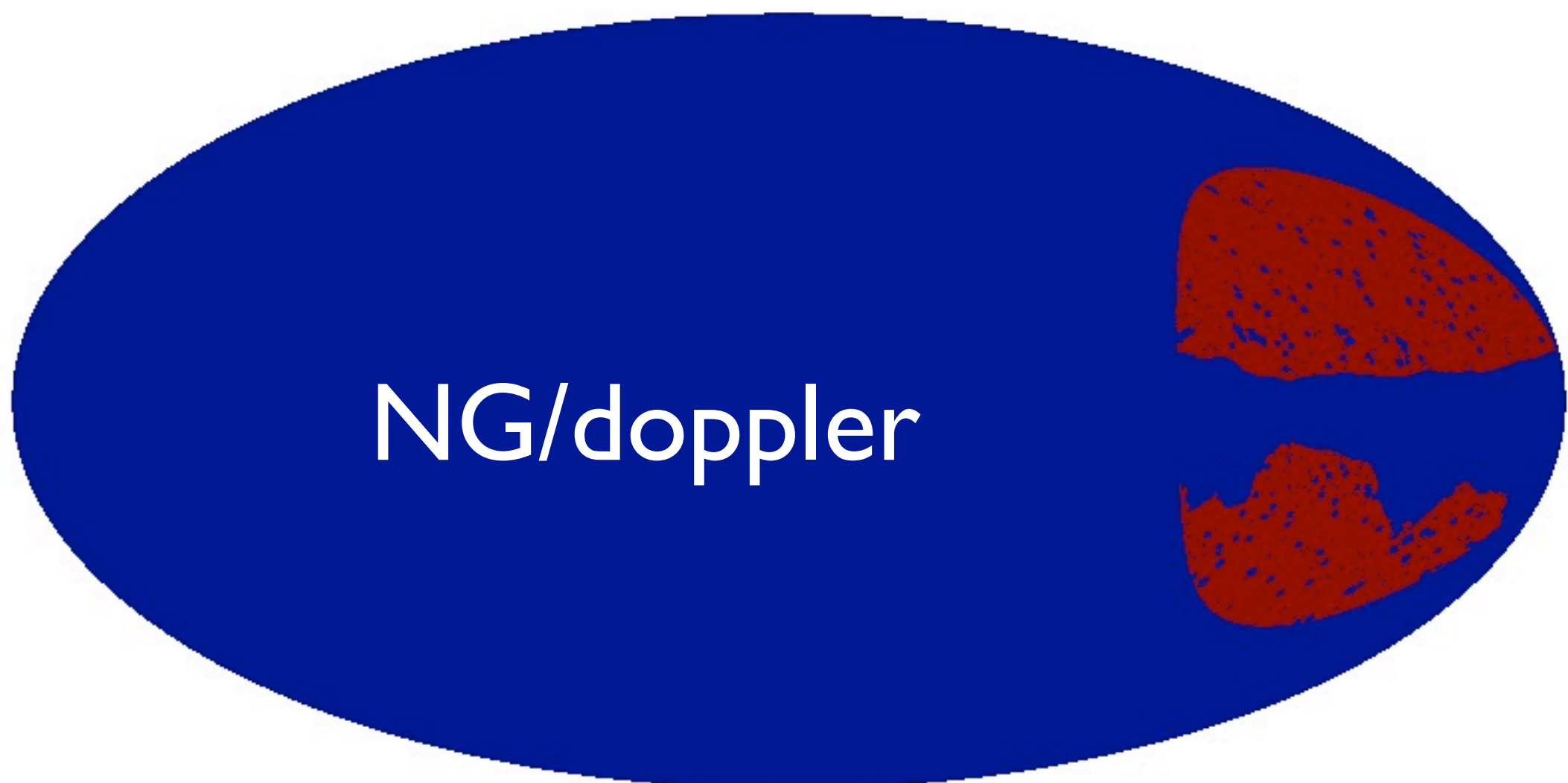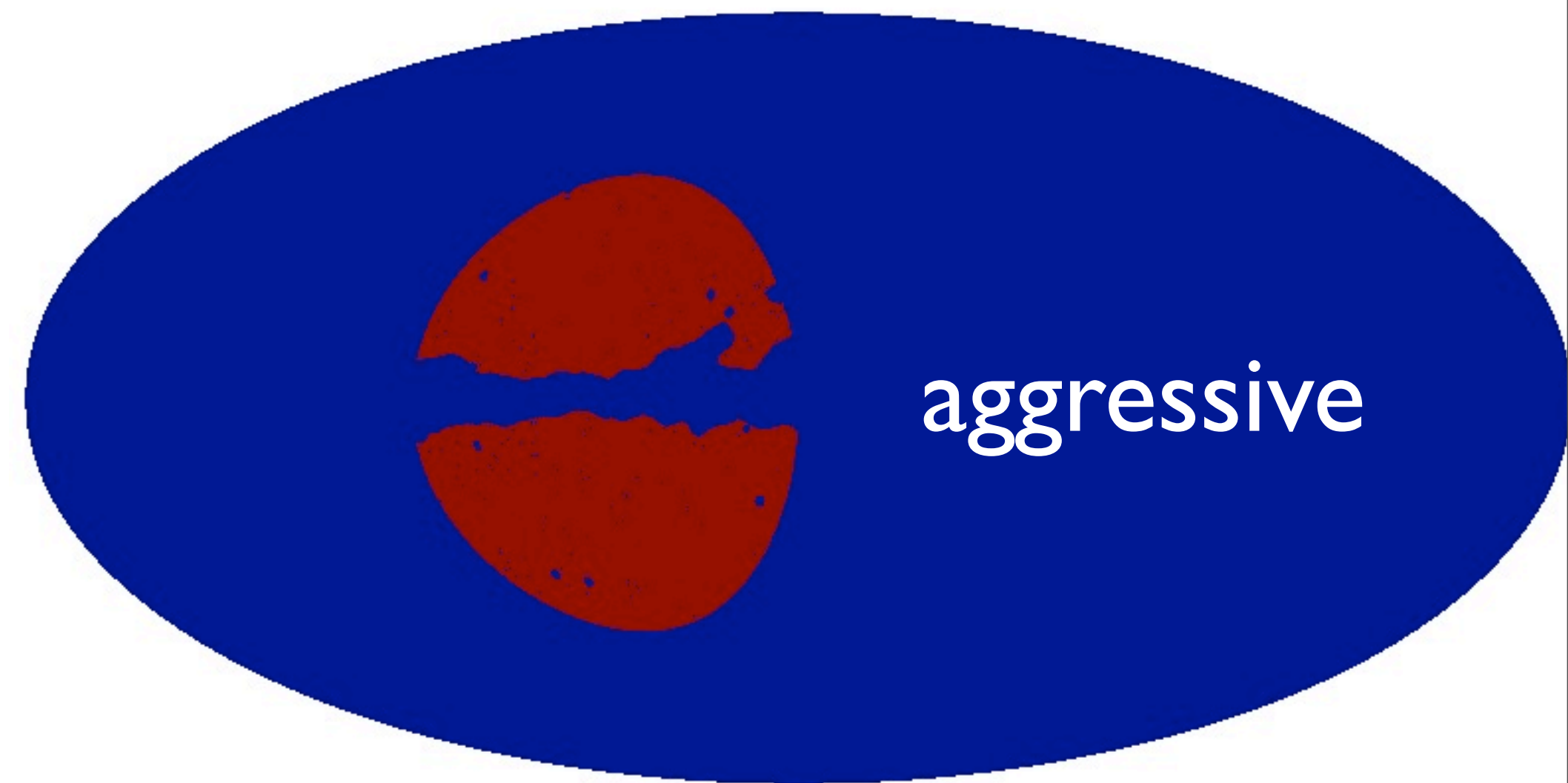avg. ratio=1.030 ± 0.005 (l_{max}=1500)
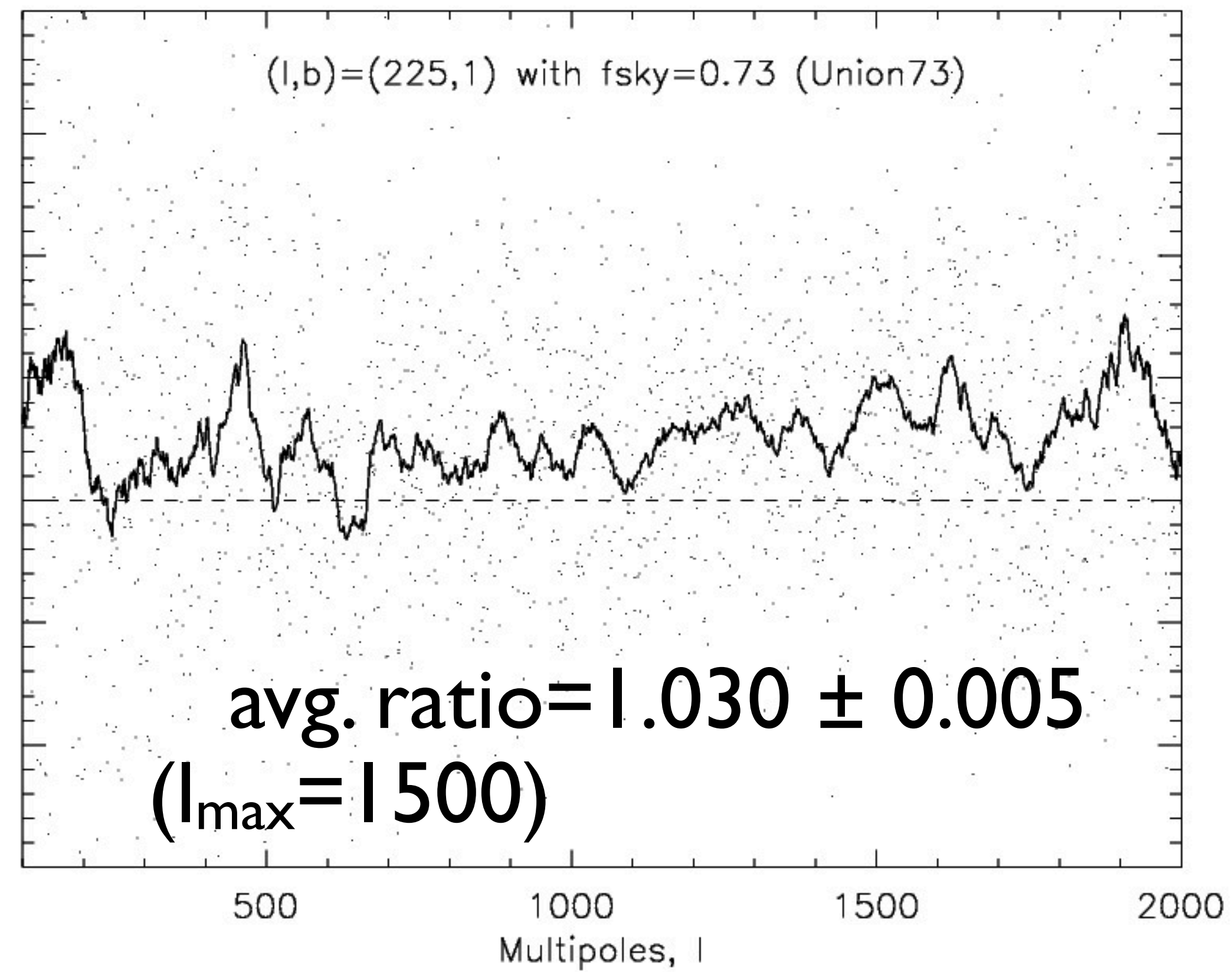
However...

- In the isotropy paper, they appear to say that their mask has 90 deg DIAMETER; rather than the radius.

Correct masks?

Now too much asymmetry?
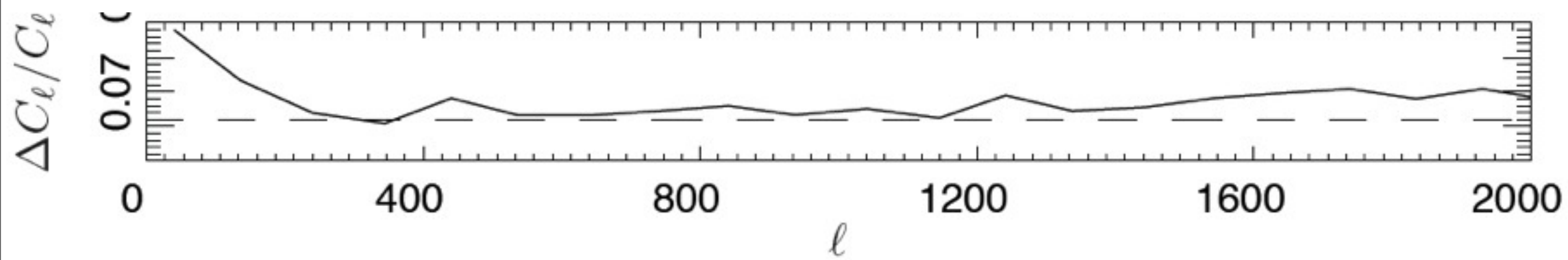

aggressive   ↕ *(Dis)agreement?*   NG/doppler

(l,b)=(225,1) with fsky=0.89 (CS−SMICA89)

avg. ratio=1.090 ± 0.021 (l$_{max}$=1500)

(l,b)=(225,1) with fsky=0.73 (Union73)

avg. ratio=1.086 ± 0.033 (l$_{max}$=1500)
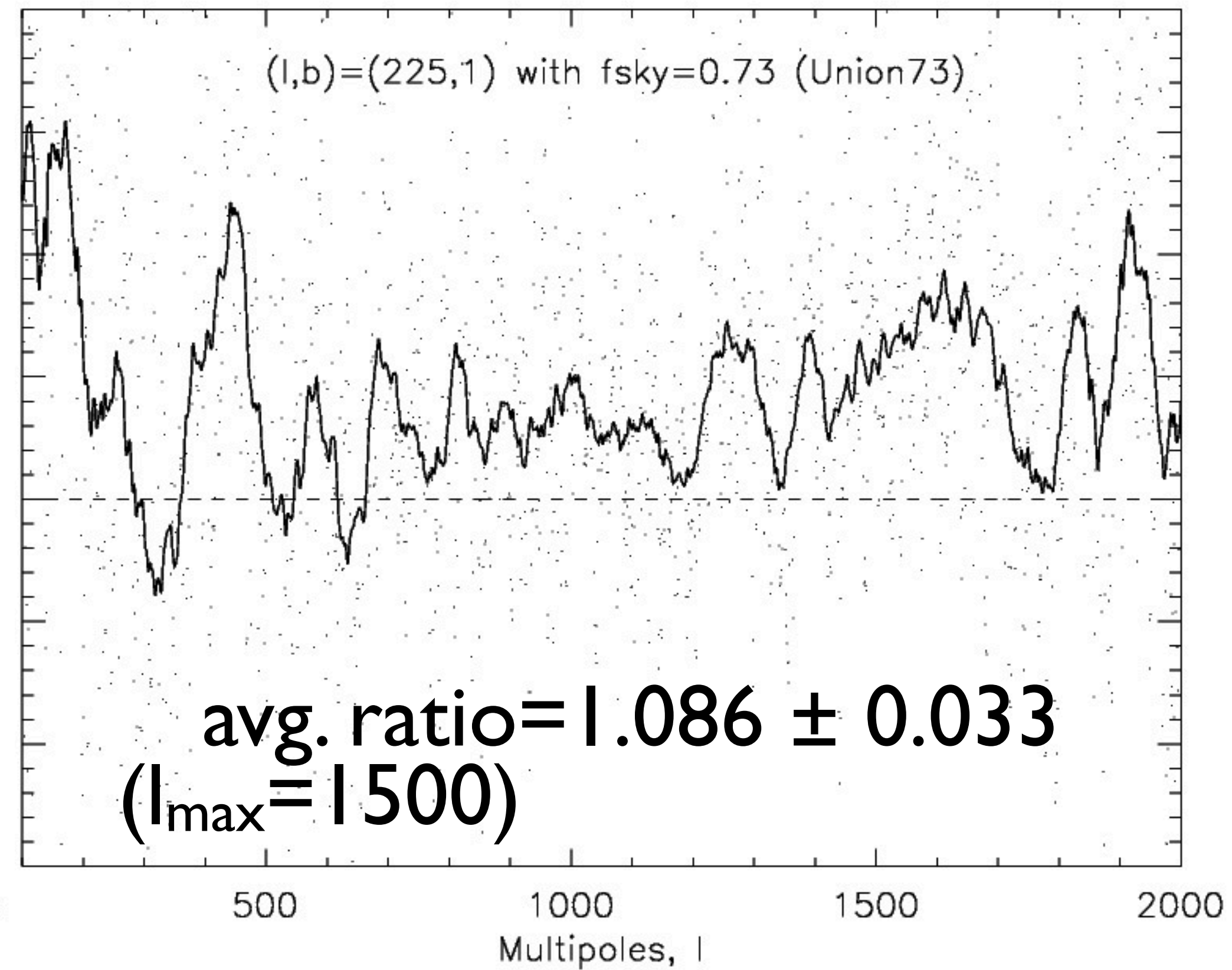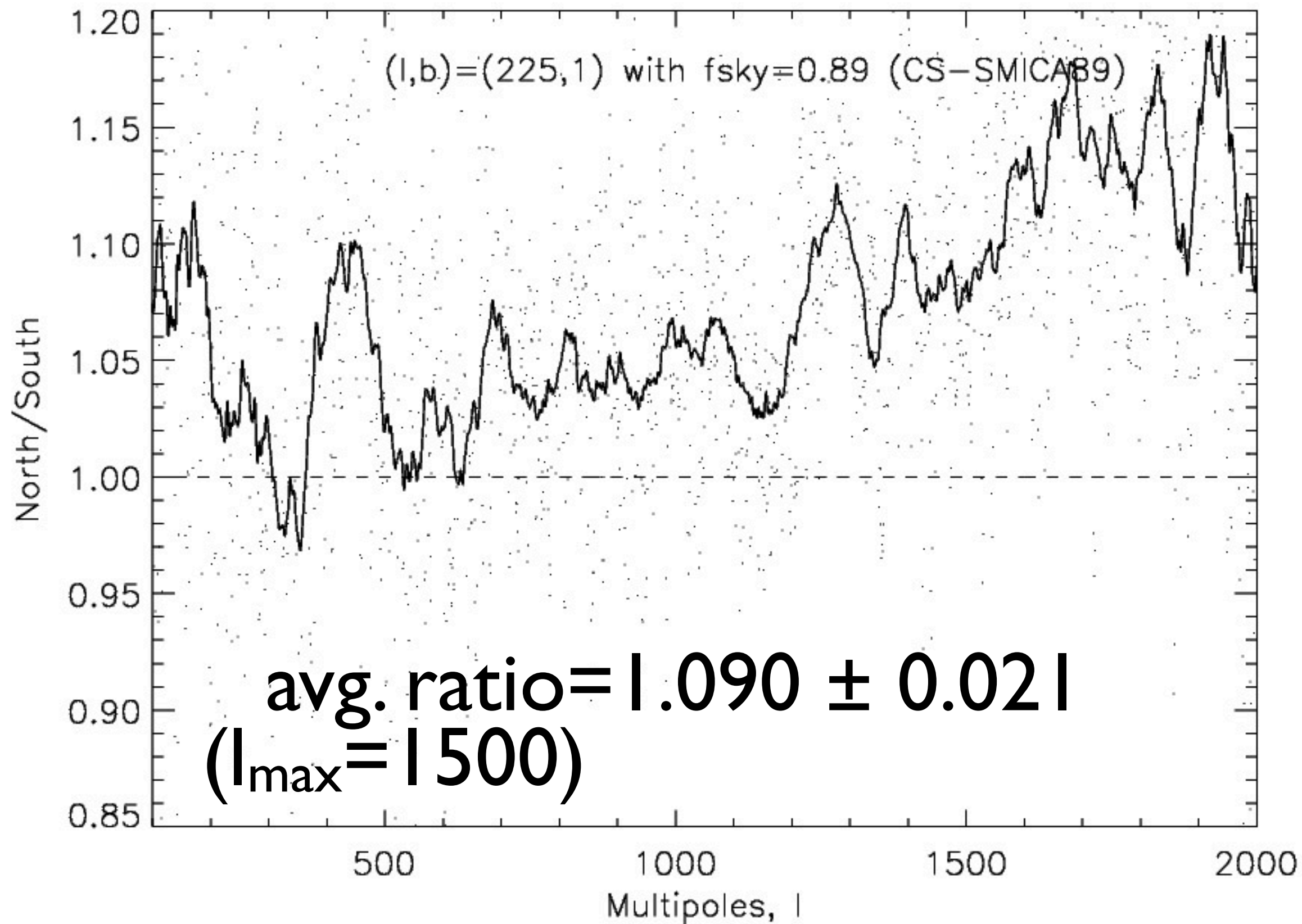
Other directions

- The low-L direction, (l,b)=(226,–17), give qualitatively similar results.

- The CMB dipole direction gives insignificant power asymmetries.

Conclusion

- Still confusing... (Which mask did the Planck team actually use? Did I do something wrong?)

- The power asymmetry at the level of 10% at high multipoles is in contradiction with the constraints from NG and Doppler analyses, *assuming that the dipolar modulation is the correct phenomenology.*

- The power asymmetry *does* appear to depend on the mask used for the analysis, and its magnitude decreases as the mask is enlarged. Not a robust feature?