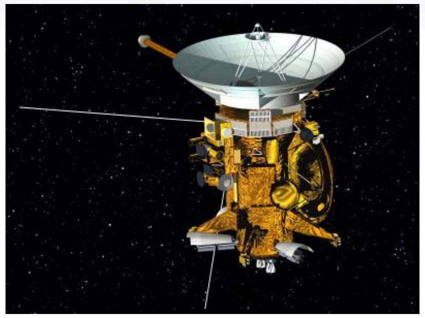

Resolving Enceladus Plume Production Along the Fractures

Ben Southworth,
Sascha Kempf
13 Aug., 2017

New results

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- Mass production (not 5kg/s)

New results

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- More large particles

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- Temporal variability

New results

- Mass production (not 5kg/s)
- More large particles
- Temporal variability
- More questions than answers

Outline

- Plumes - what, where and why?
- Resolving mass production
- Implications on particle distributions
- Surface deposition and tilted jets

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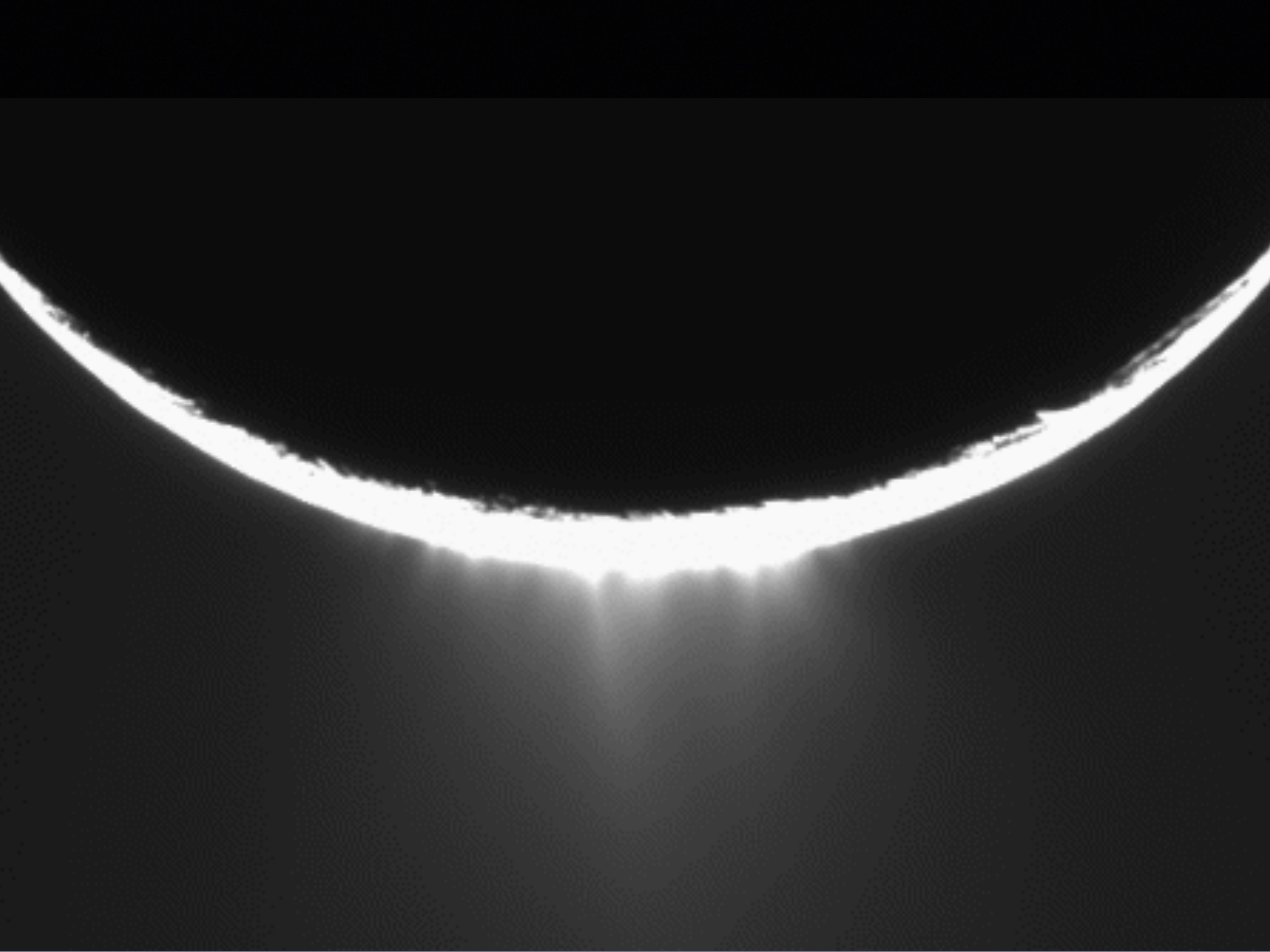
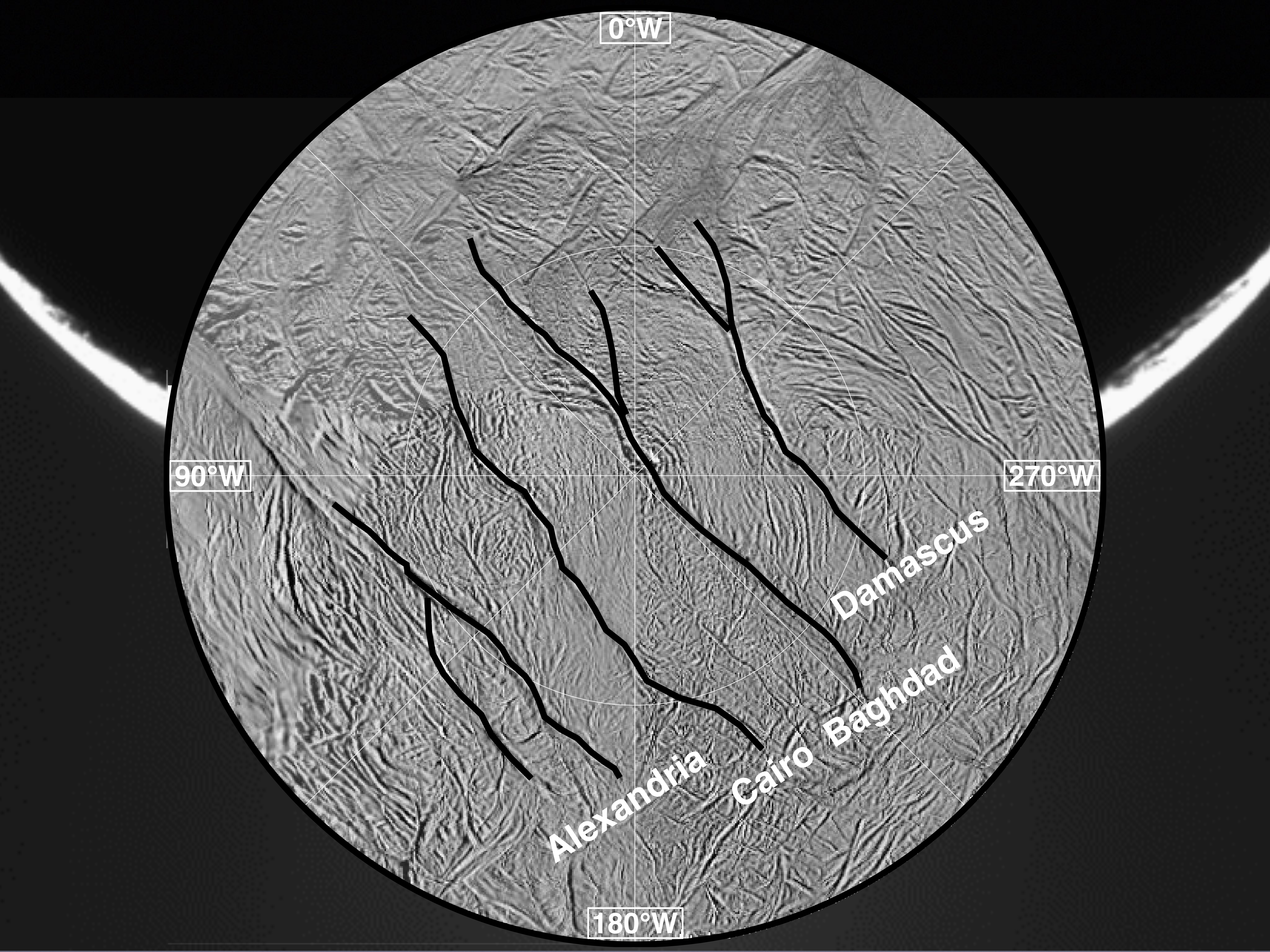


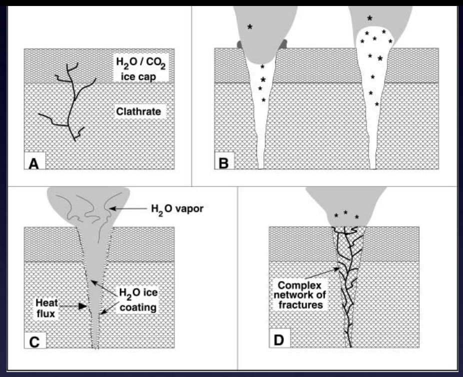

0°W
90°W
270°W
180°W
Damascus
Baghdad
Cairo
Alexandria

Which one?

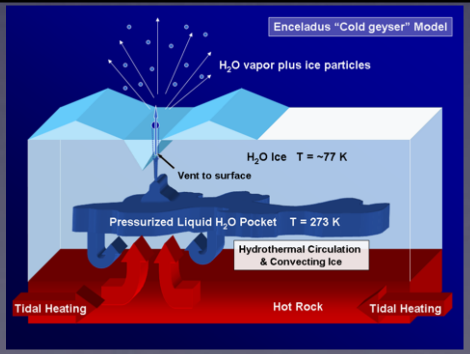
High

CH_4 and N_2 fraction in plume gas

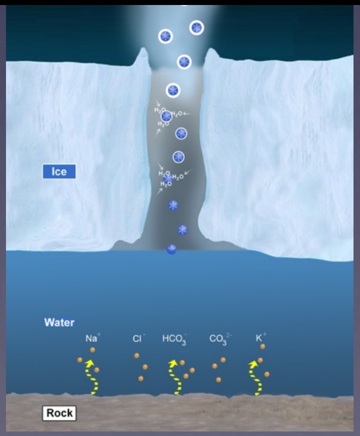
Frigid Faithful



Cold Faithful



Deep Source



Strong

Ice plume stratification

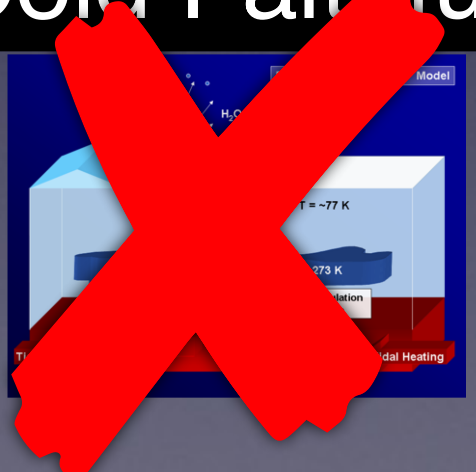
Which one?

High

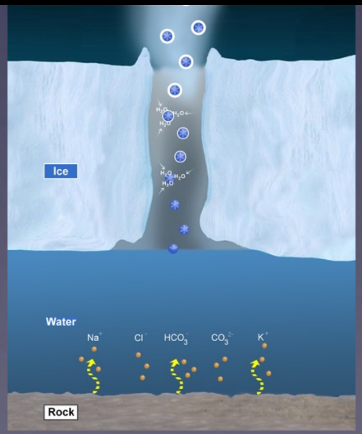
CH_4 and N_2 fraction in plume gas

Frigid Faithful

Cold Faithful



Deep Source



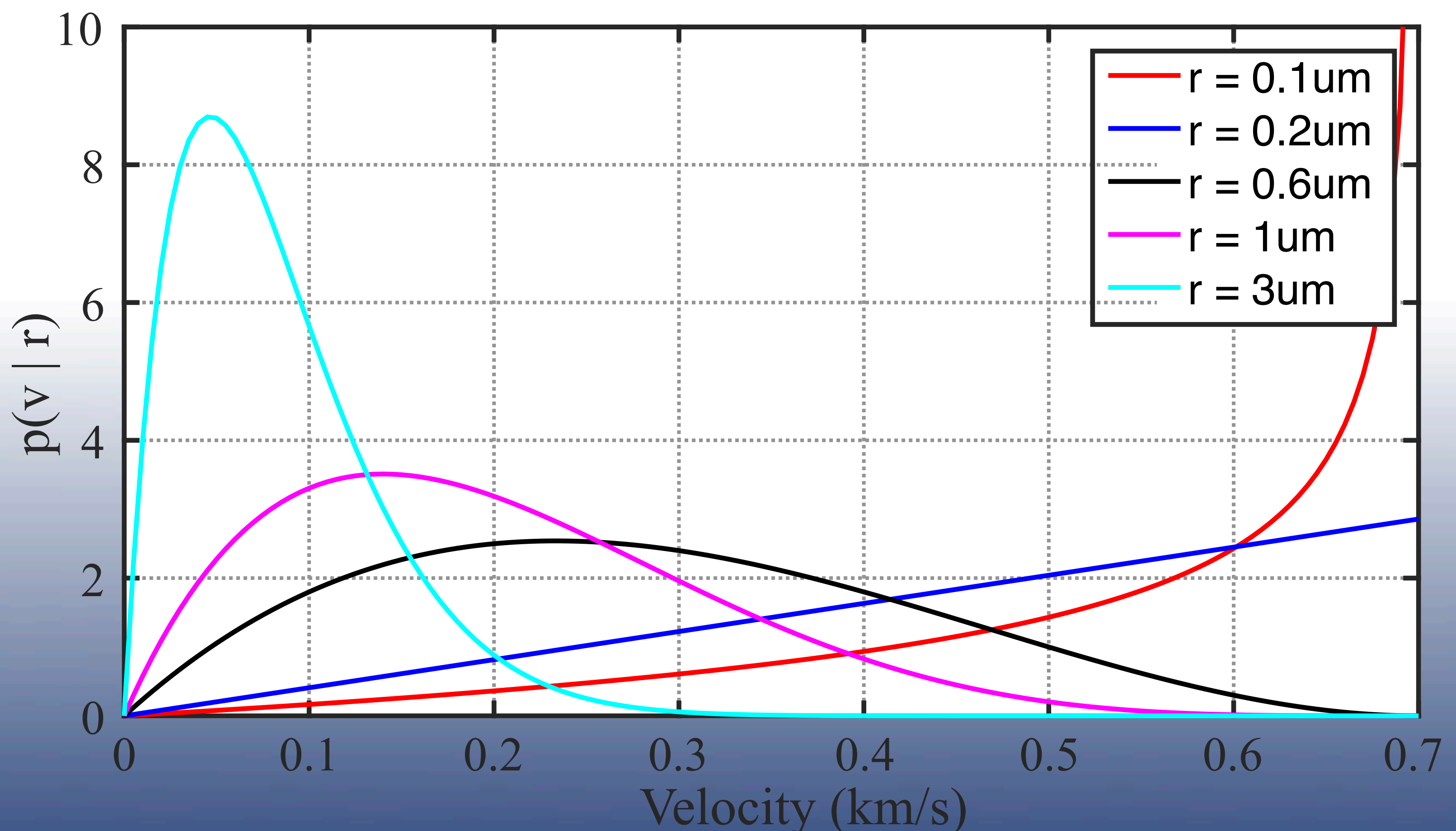
Strong

Ice plume stratification

Plume Model

- Deep source particle speed distribution taken from Schmidt et al. (2008):

$$p(v|r) = \left(1 + \frac{r}{r_c}\right) \frac{r}{r_c} \frac{v}{v_{gas}^2} \left(1 - \frac{v}{v_{gas}}\right)^{\frac{r}{r_c} - 1}$$



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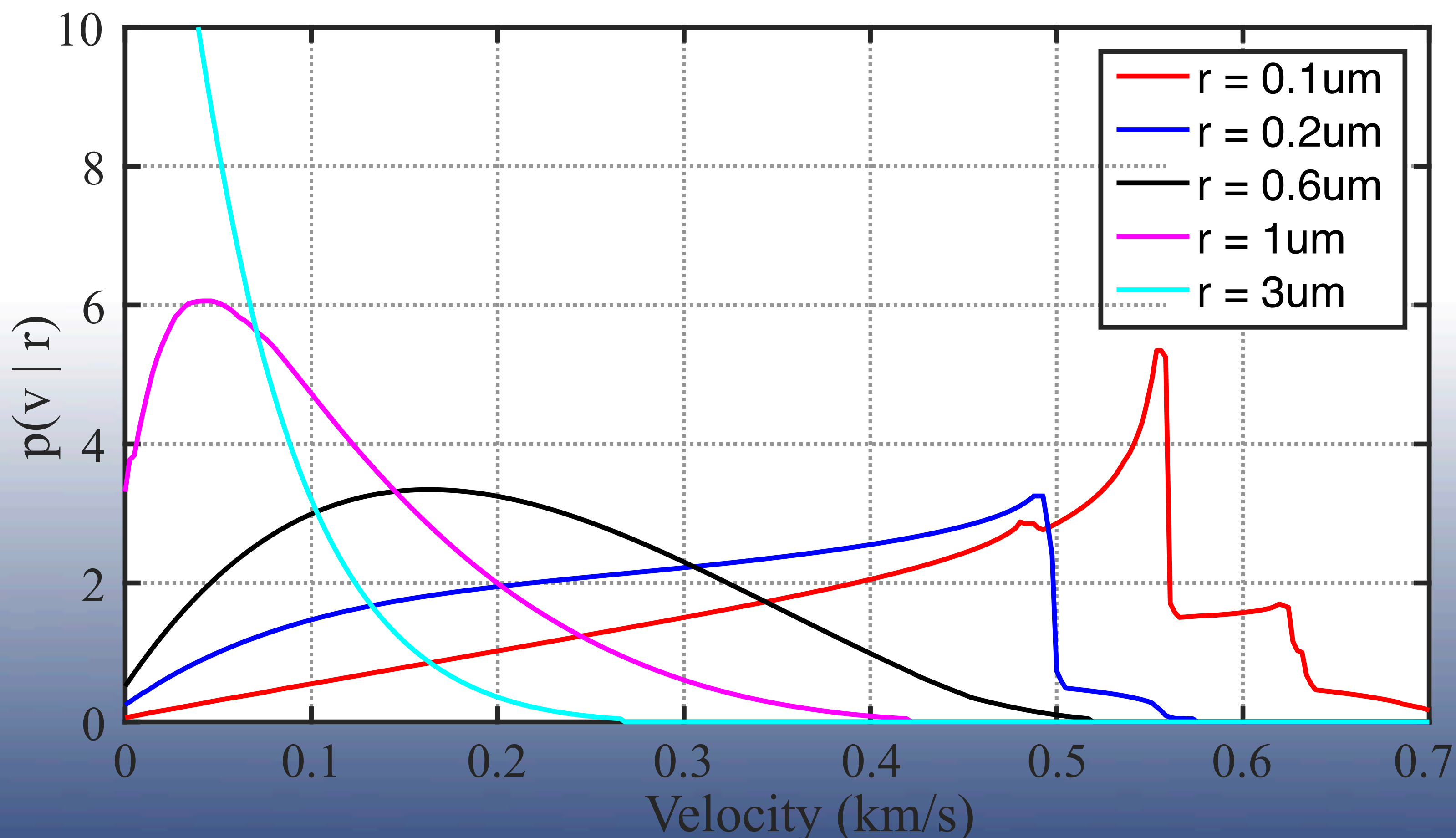

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- Assume polar ejection angle follows $\cos^2$-distribution

Equations of motion

$$\ddot{\mathbf{r}} = -\frac{\mu_P}{|\mathbf{r}|^5}\left\{\left[|\mathbf{r}|^2 - \frac{3}{2}J_2 R_P^2(5\sin^2\delta - 1)\right]\mathbf{r} + 3J_2 R_P^2 \mathbf{e}_z r_z\right\} - \ldots$$

$$\mu_M \frac{\mathbf{r} - \mathbf{r}^M}{|\mathbf{r} - \mathbf{r}^M|^3} + \frac{Q_d}{m_d}\left(\mathbf{E}^c(\mathbf{r}) + \mathbf{r}' \times \mathbf{B}^P(\mathbf{r})\right)$$

Accounts for planet's gravity and second moment, moon's gravity, and particle charging.

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Accounts for planet's gravity and second moment, moon's gravity, and particle charging.

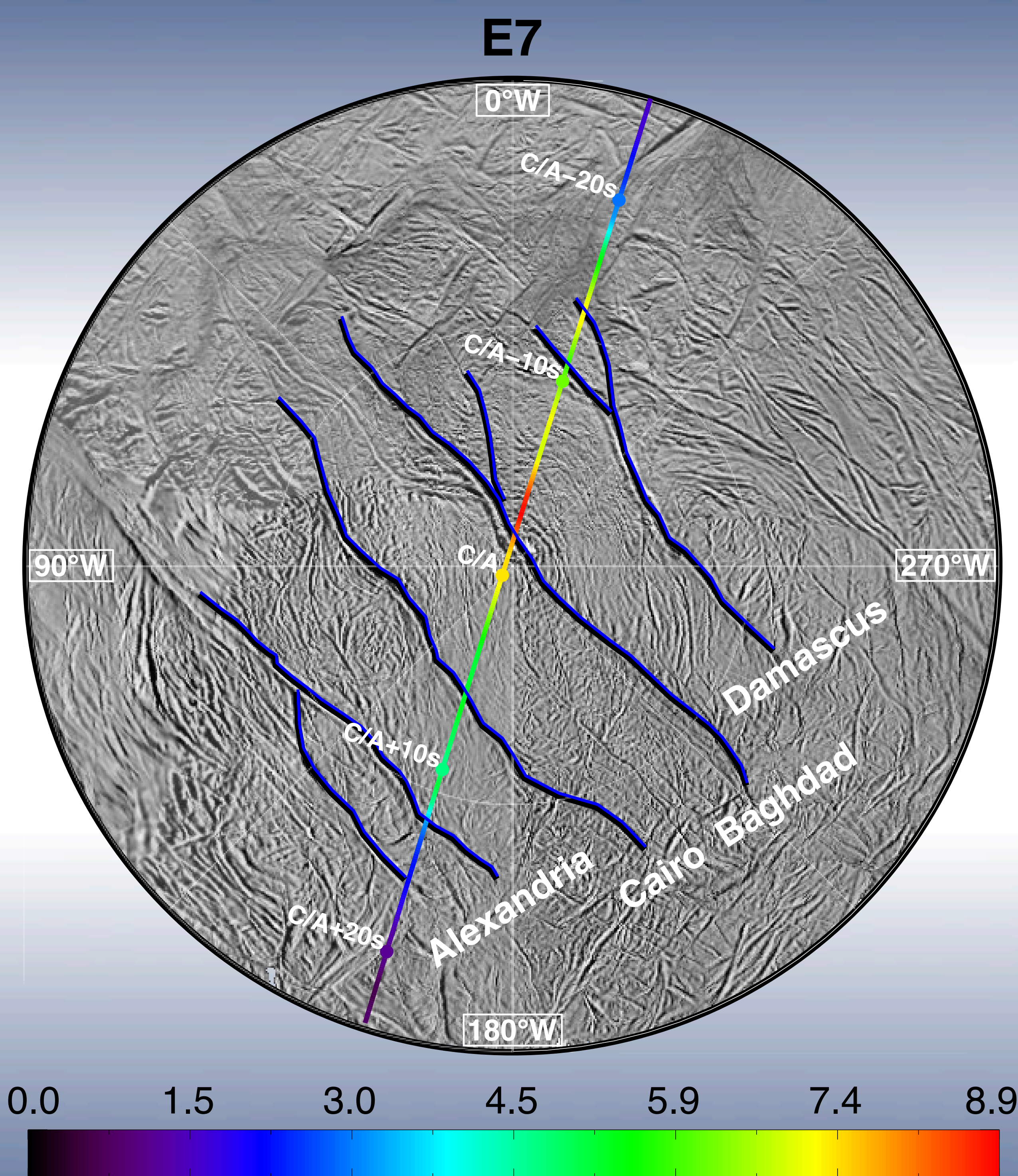
—> Simulate millions of particles

- Create quasi-steady state model of plume
- Create impact rate profile on surface of moon

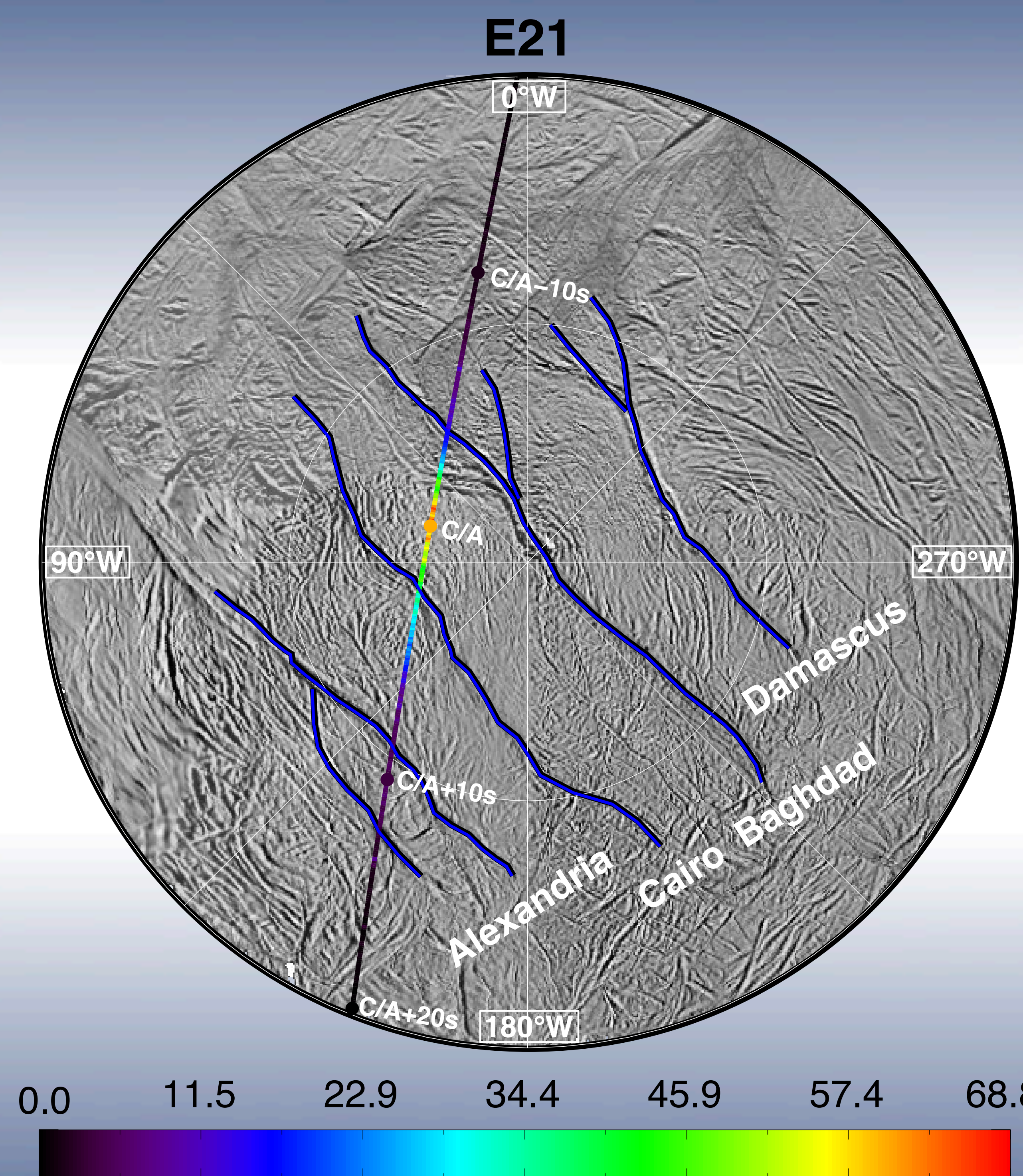
Outline

- Plumes - what, where and why?
- Resolving mass production
- Implications on particle distributions
- Surface deposition and tilted jets

Two low-altitude flybys



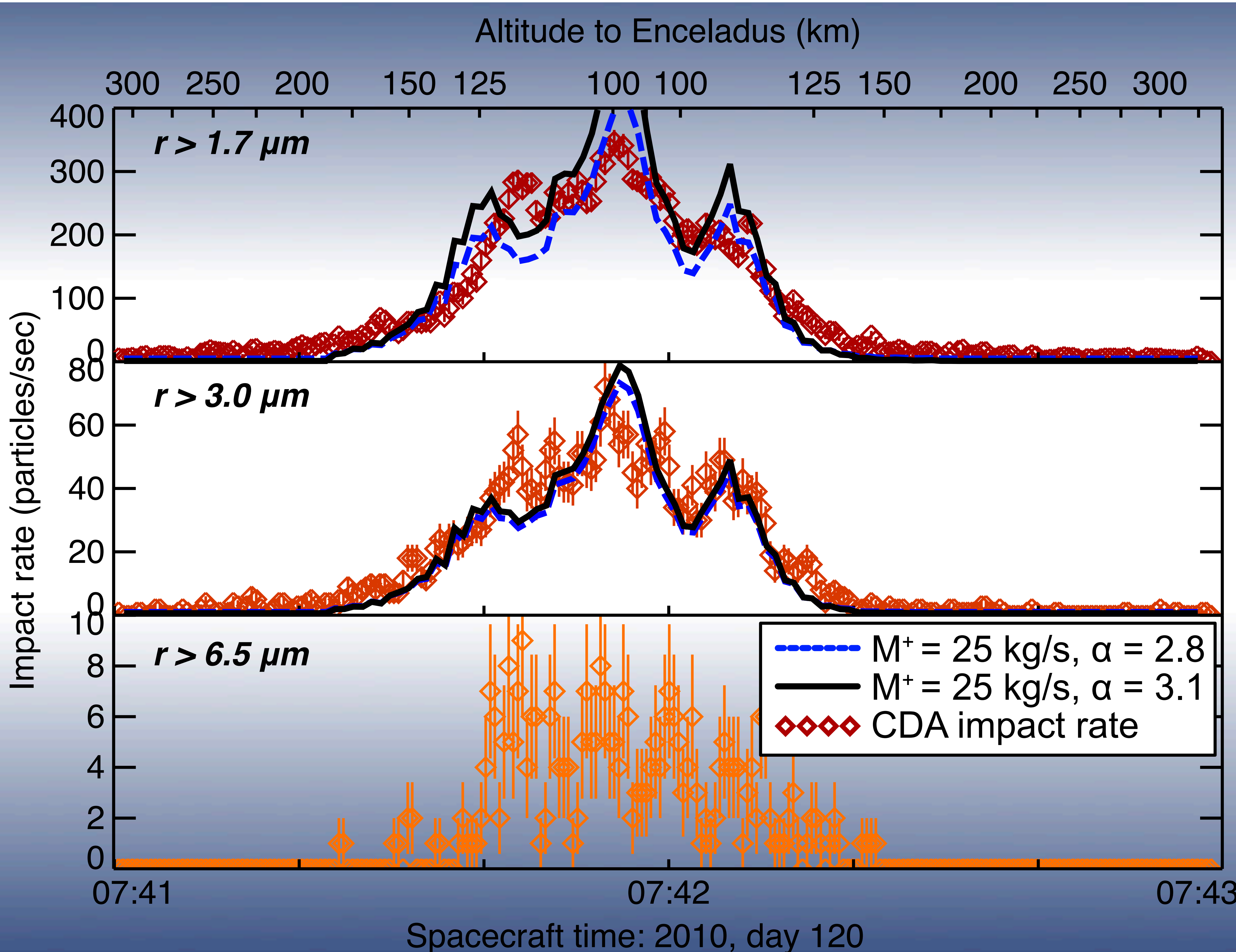
Number Density of Grains >1.7μm (m^{-3})



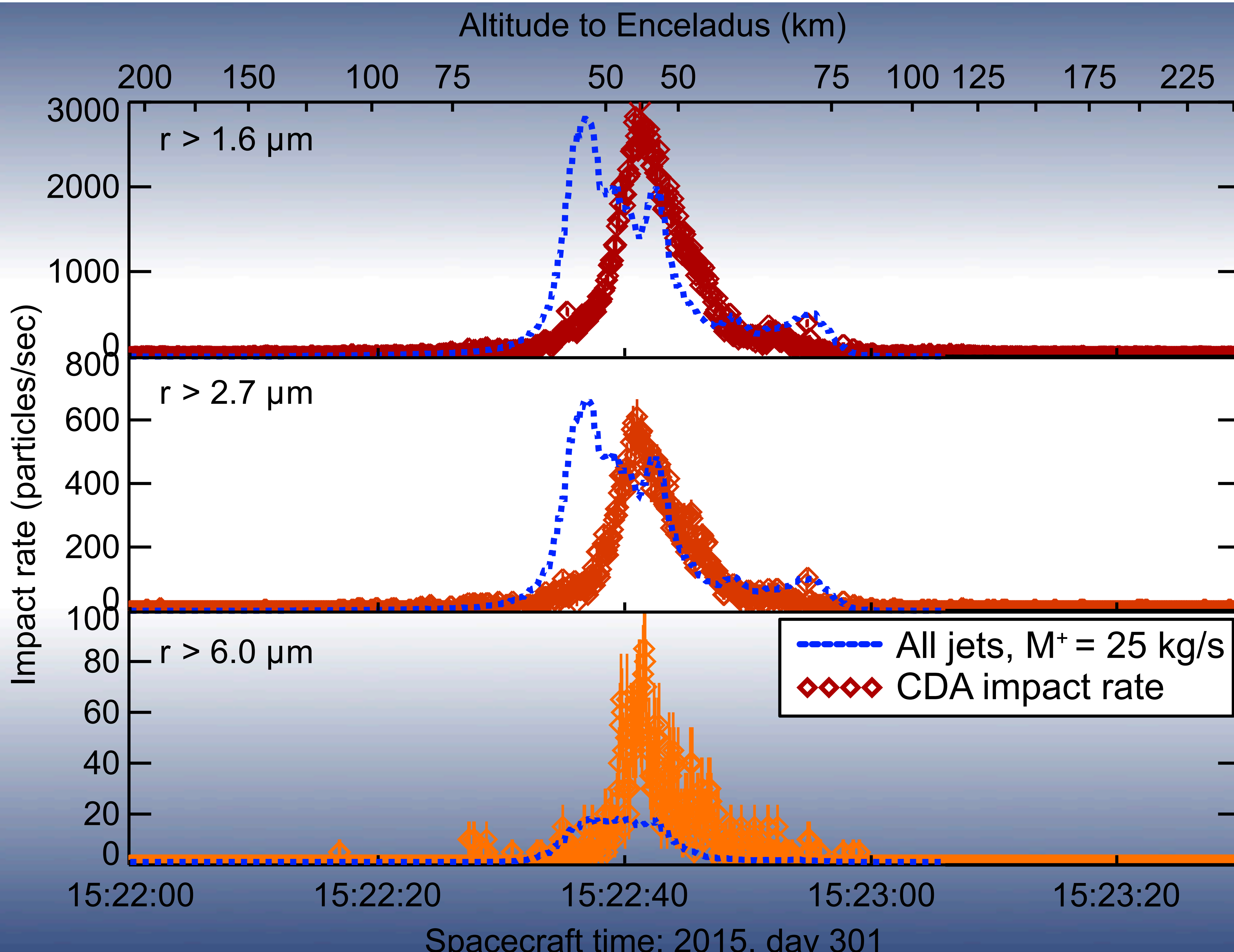
Number Density of Grains >1.6μm (m^{-3})

Plume model | Mass production | Particle distributions | Surface deposition

E7 flyby

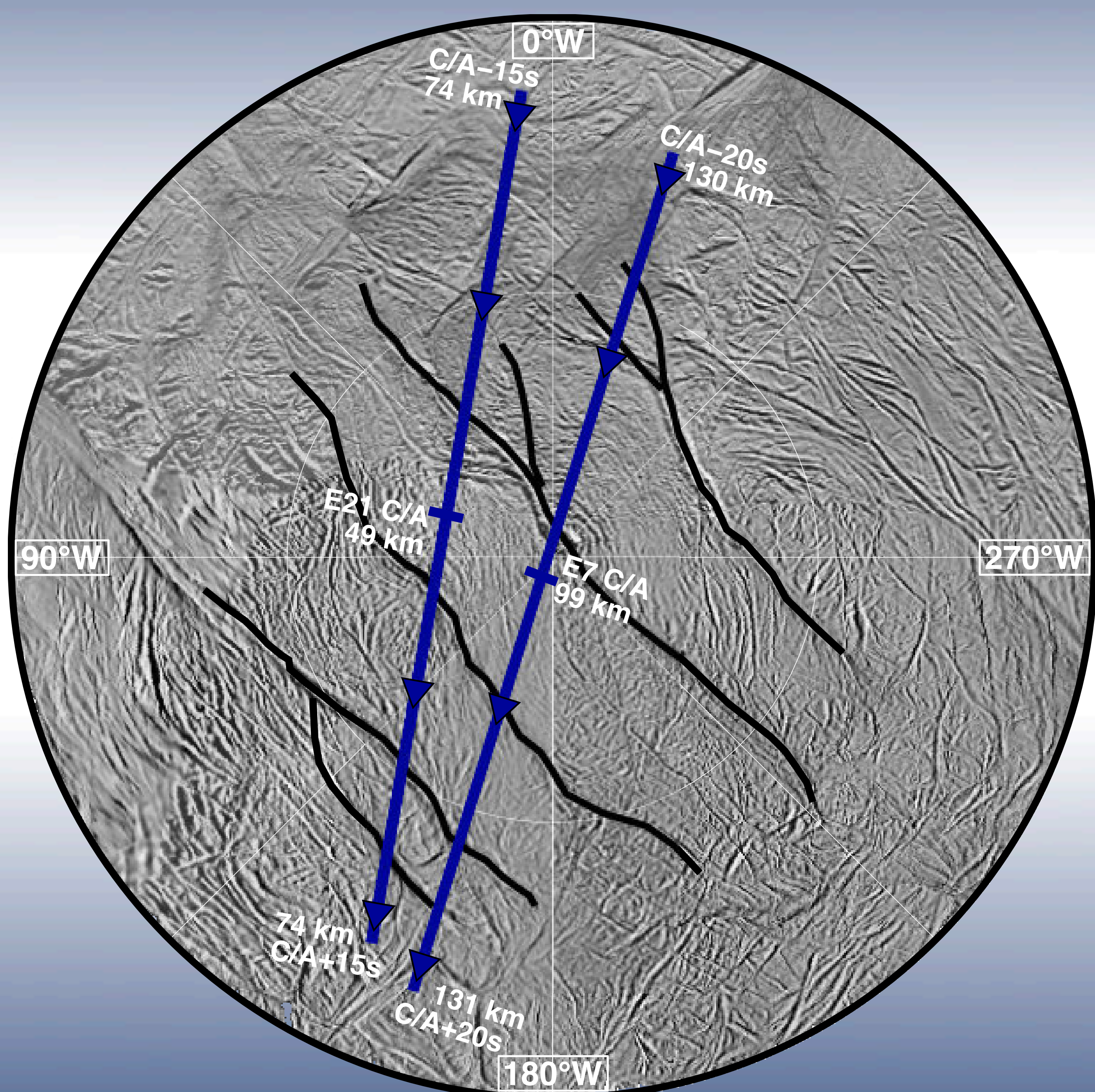


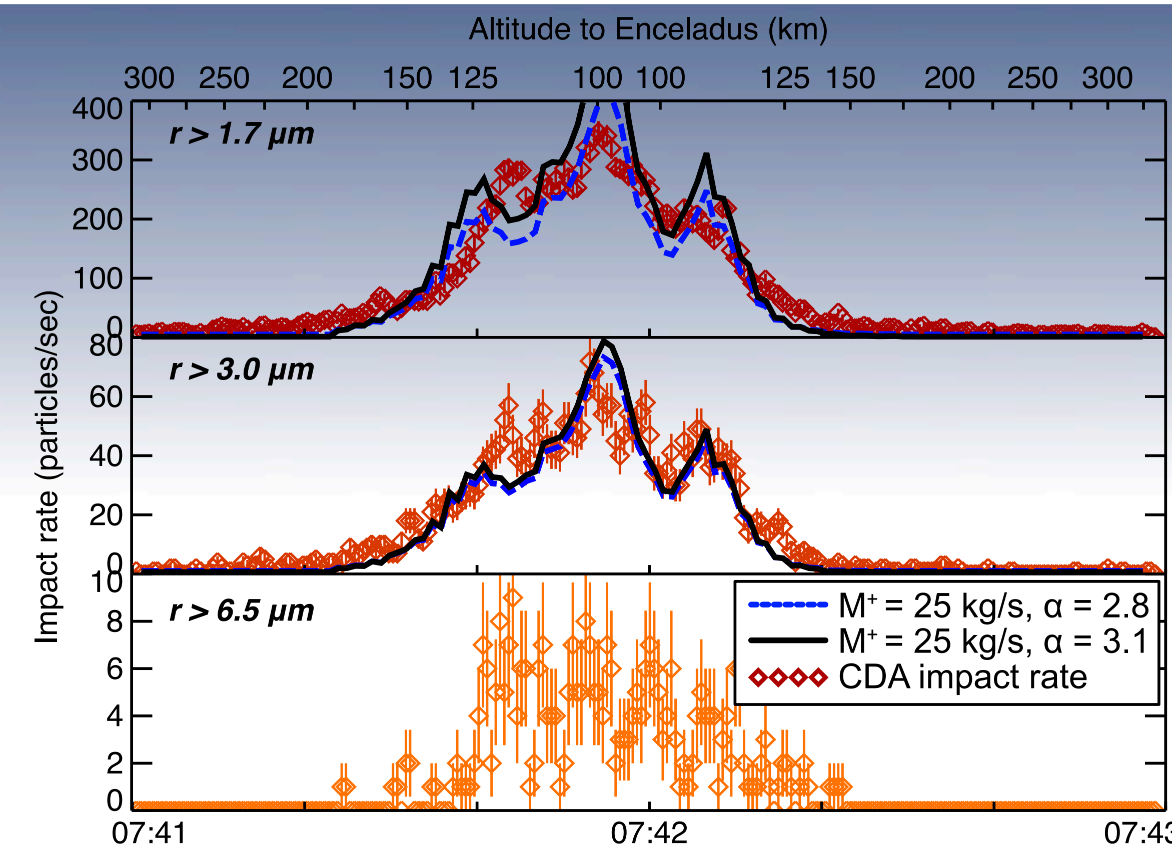
E21 flyby

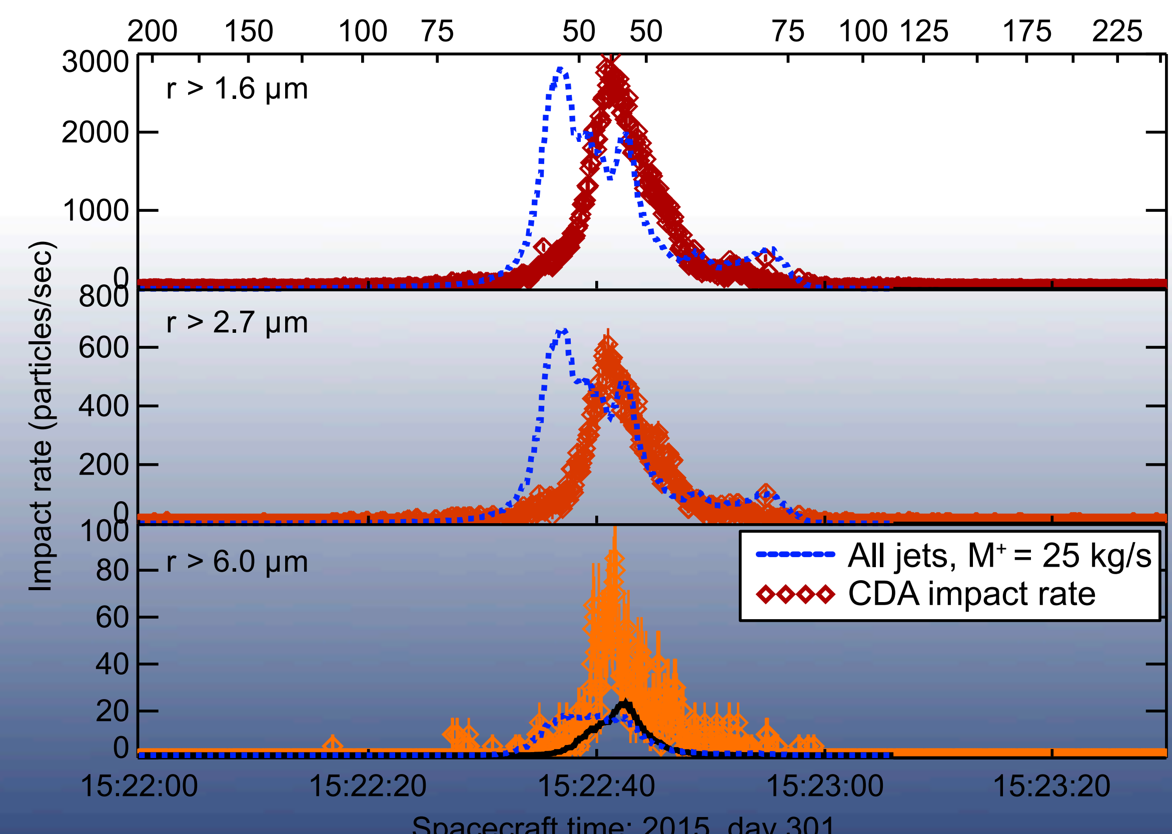


Altitude to Enceladus (km)
200
150
100
75
50
50
75
100
125
175
225
3000
2000
1000
0
r > 1.6 μm
800
600
400
200
0
r > 2.7 μm
100
80
60
40
20
0
r > 6.0 μm
All jets, M+ = 25 kg/s
CDA impact rate
Impact rate (particles/sec)
15:22:00
15:22:20
15:22:40
15:23:00
15:23:20
Spacecraft time: 2015, day 301

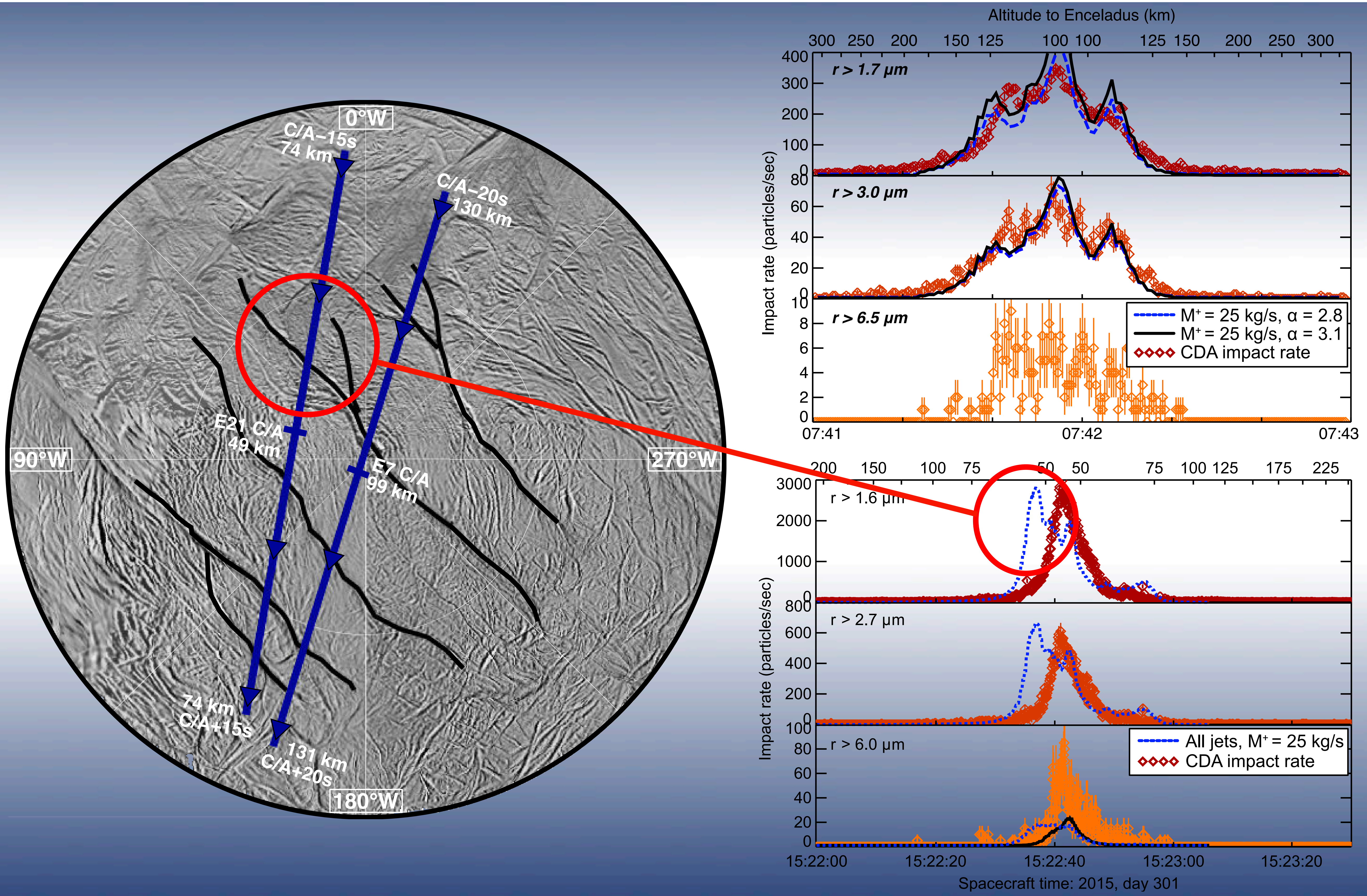
What happened in E21?



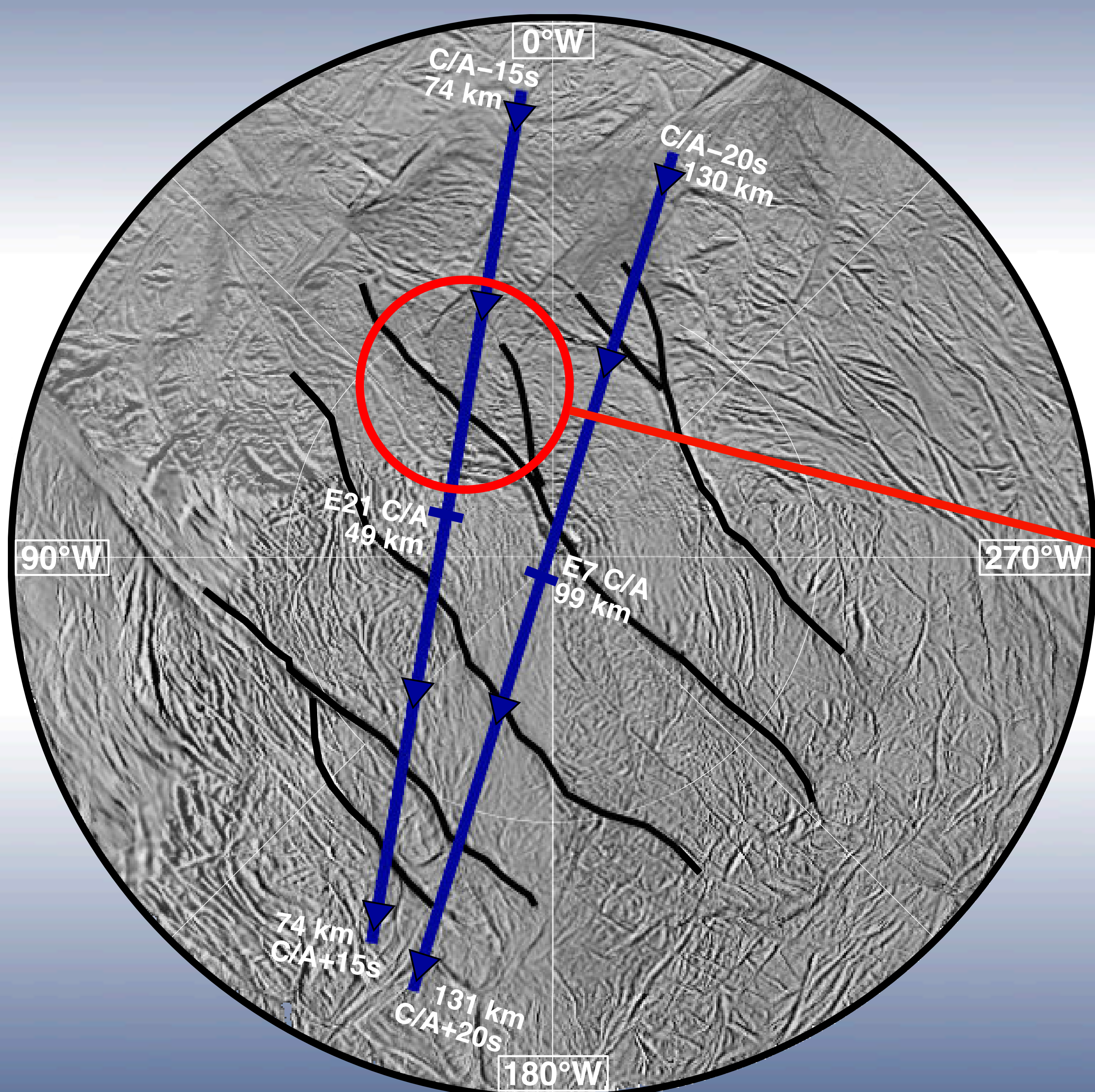


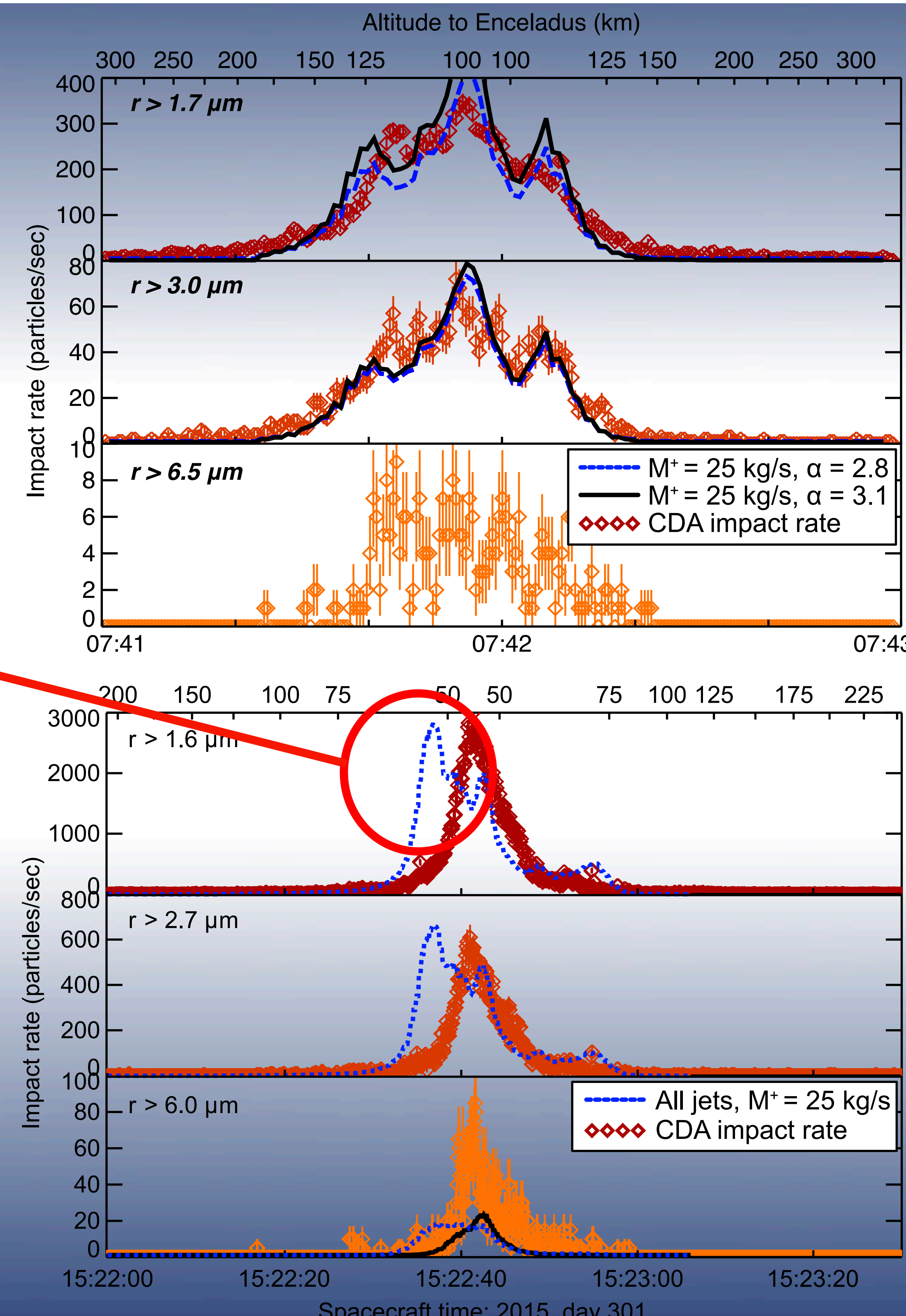


What happened in E21?

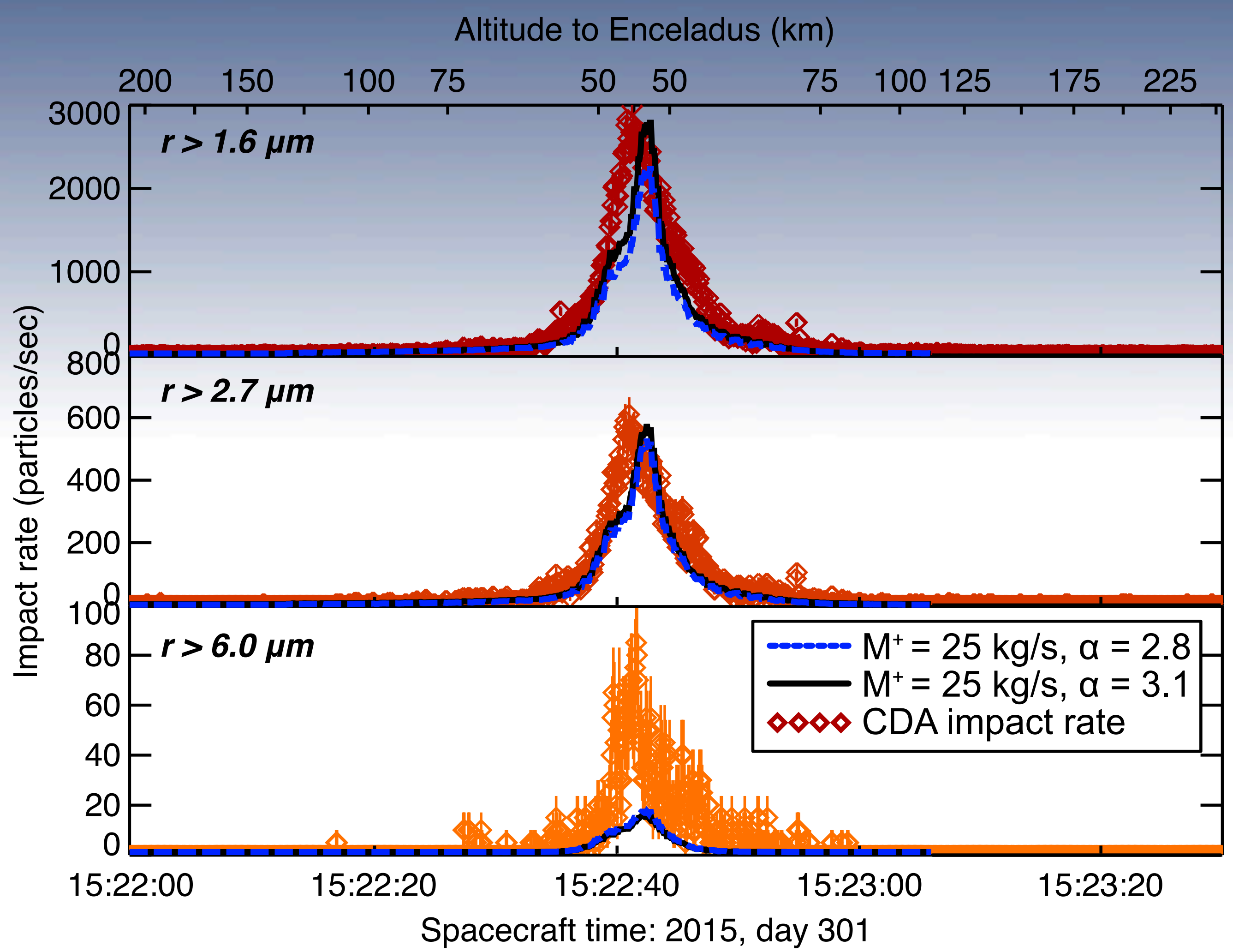


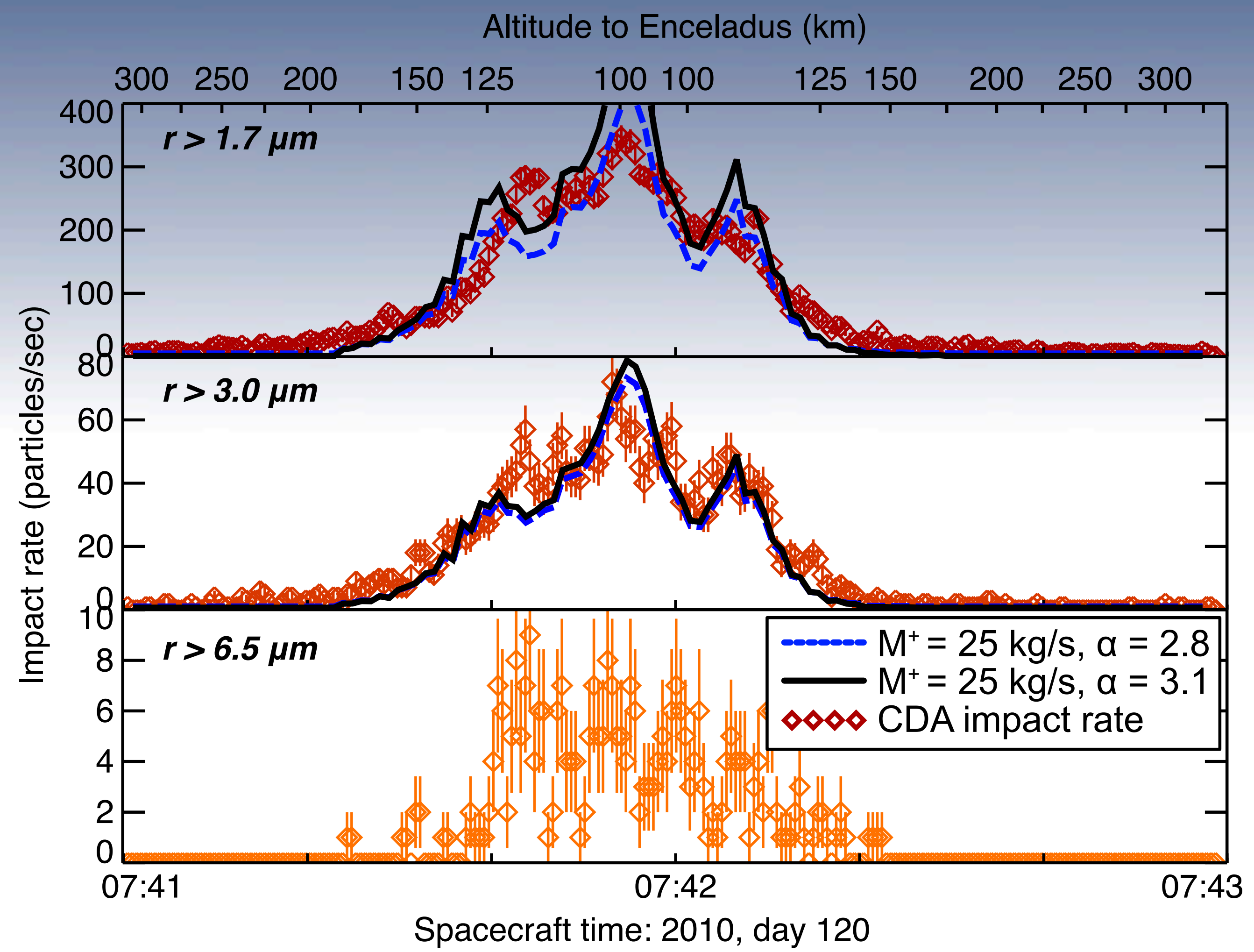
Temporal variation



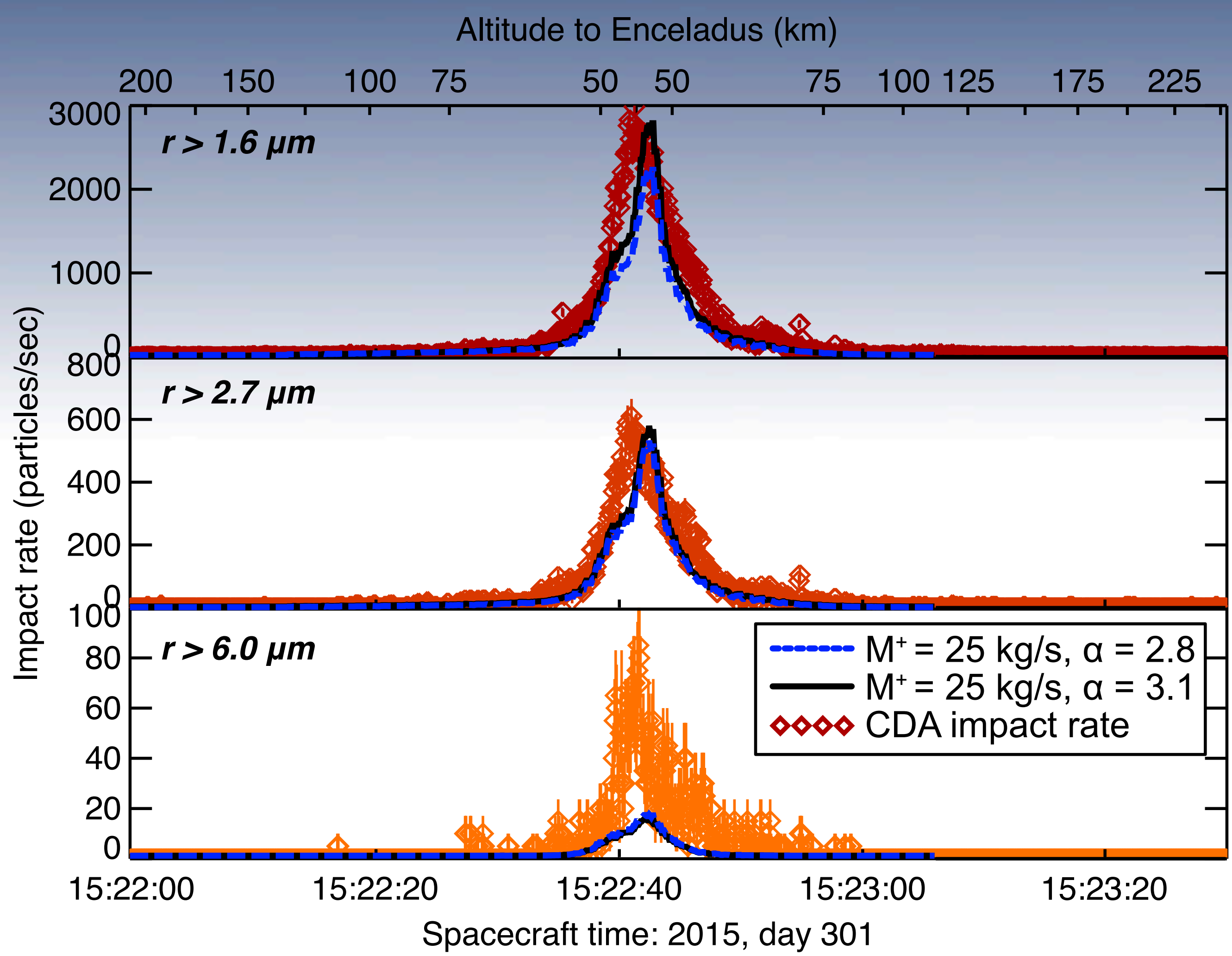


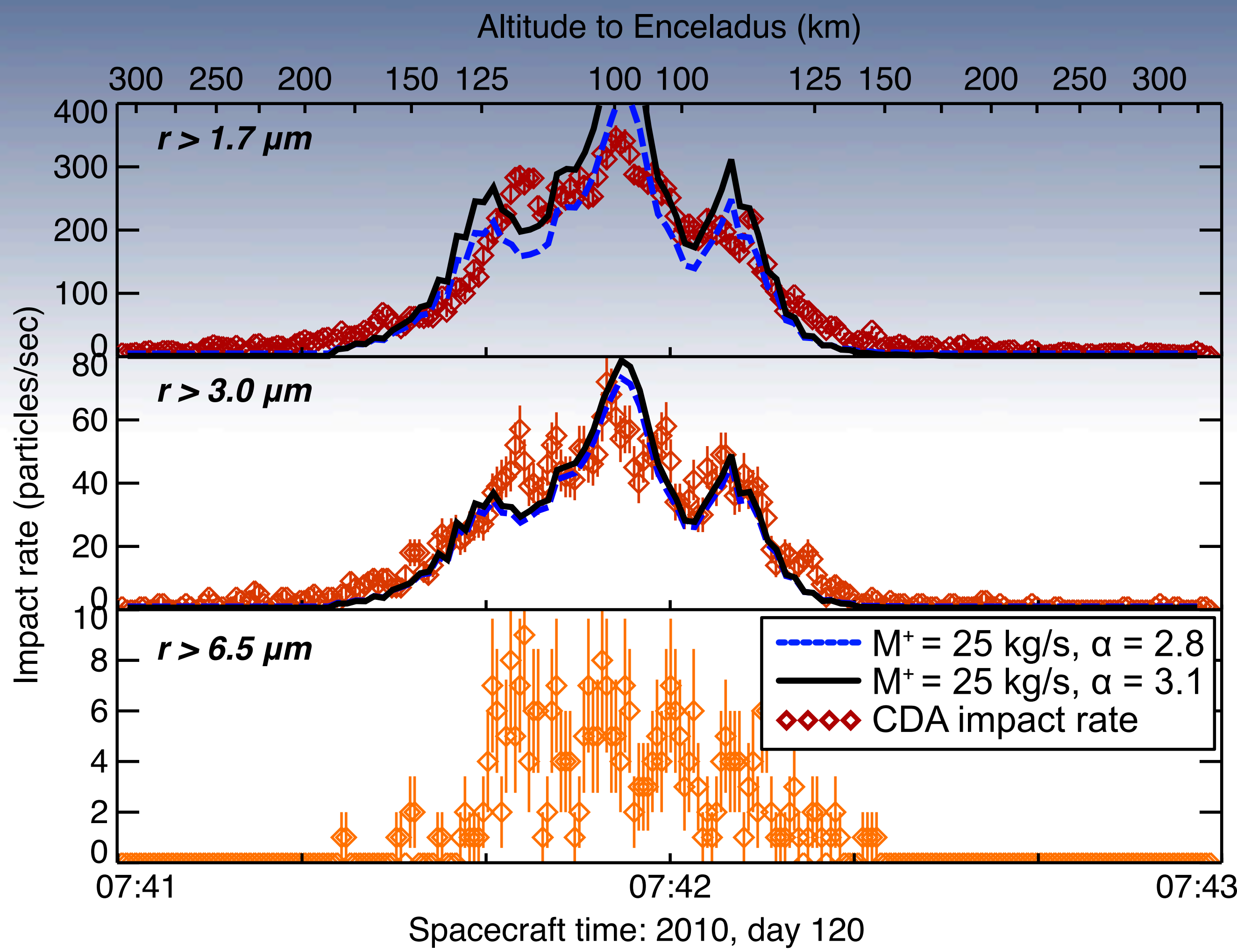
Mass production





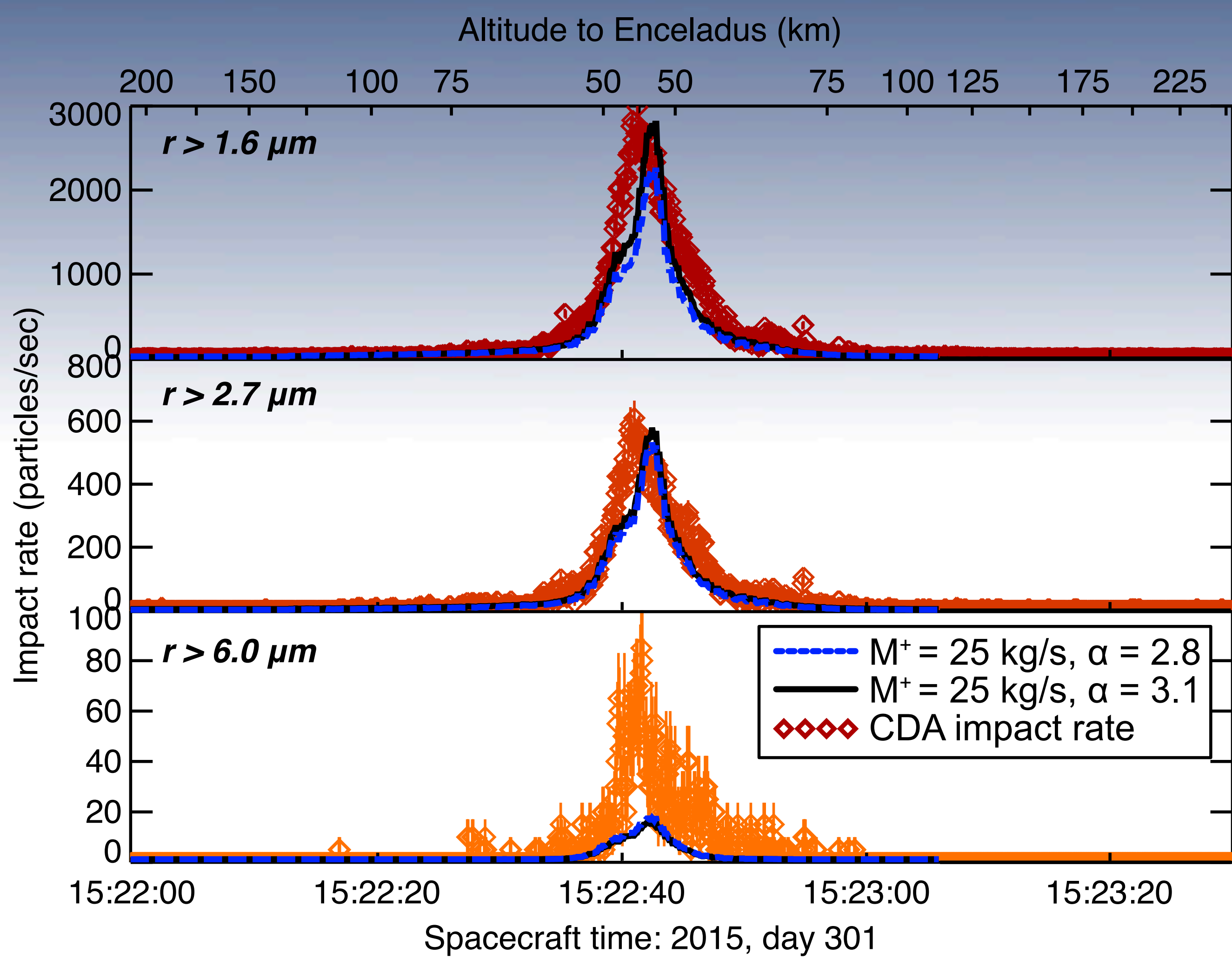
Mass production

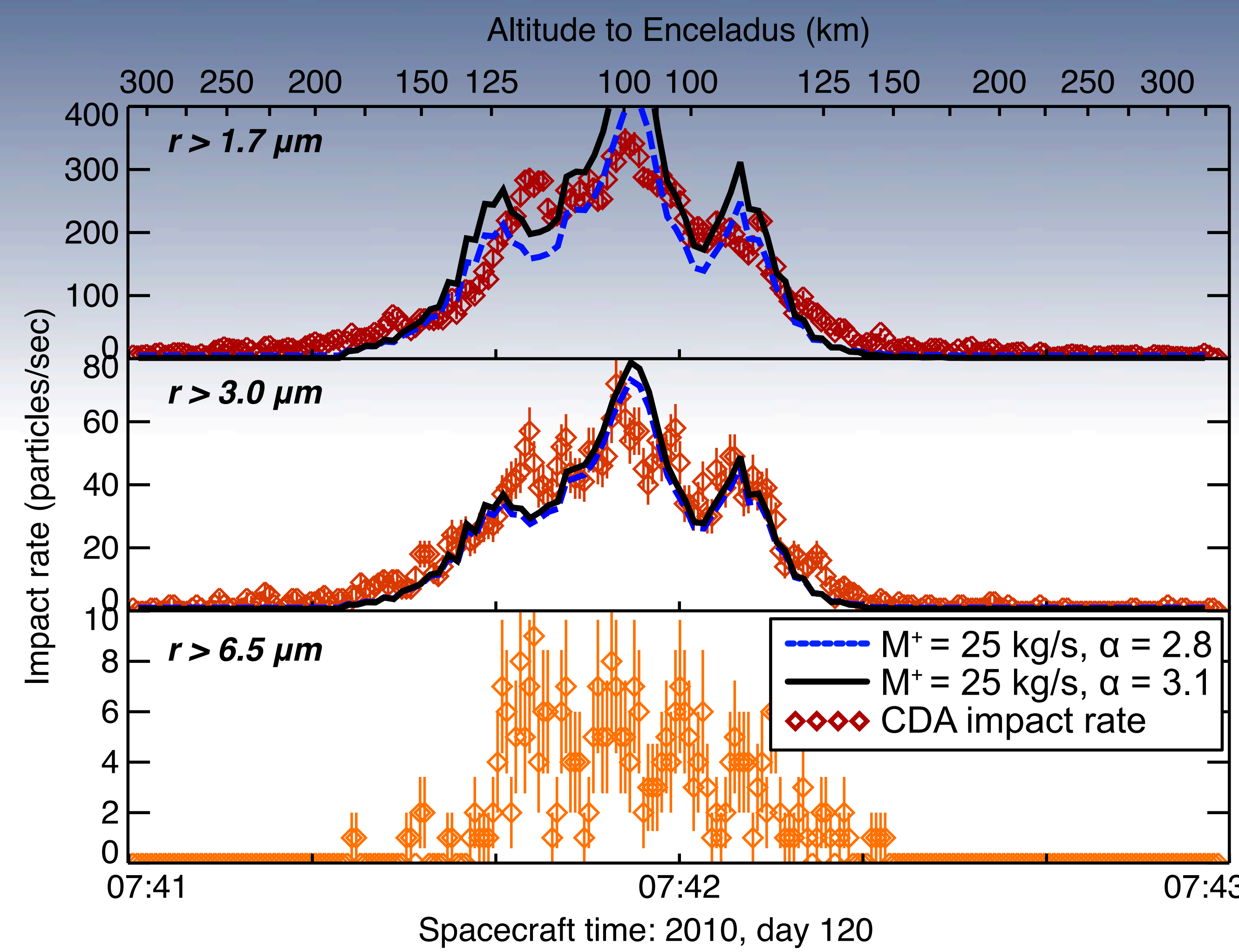




- Estimates vary from 5 kg/s to > 50 kg/s

Mass production





- Estimates vary from 5 kg/s to > 50 kg/s
- CDA data most direct measurement of mass production — ~25 kg/s

Outline

- Plumes - what, where and why?
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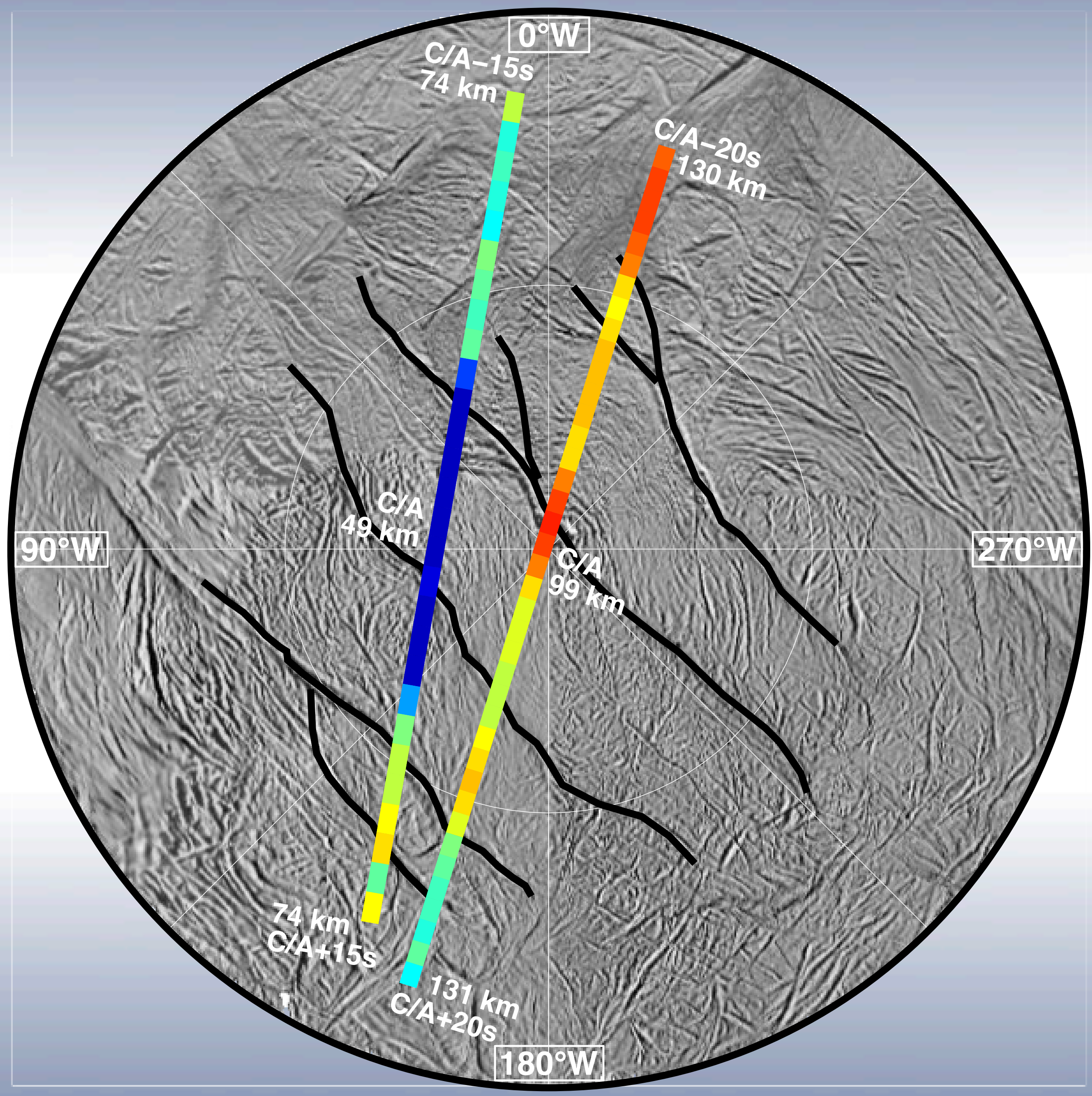
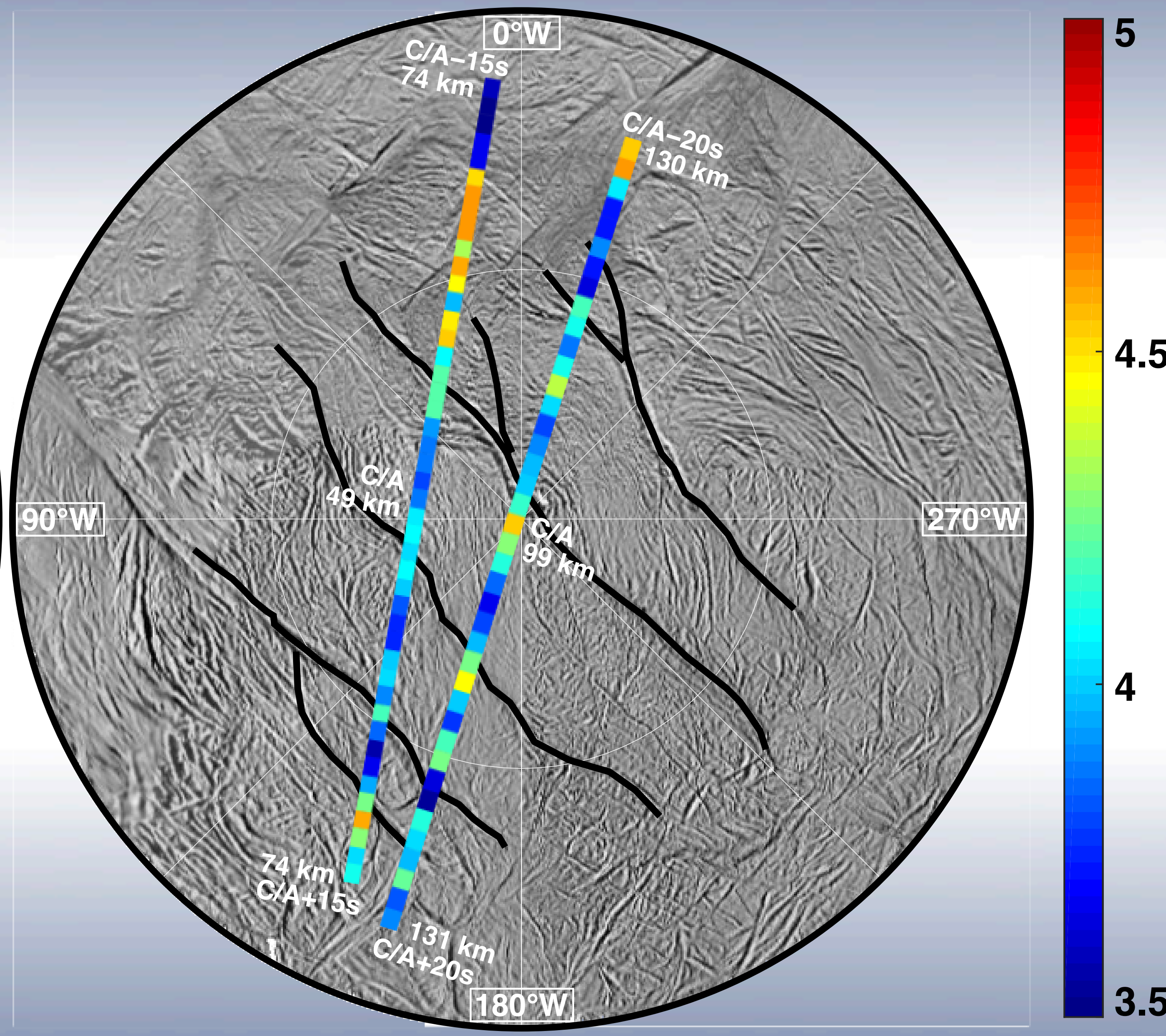
Size distribution

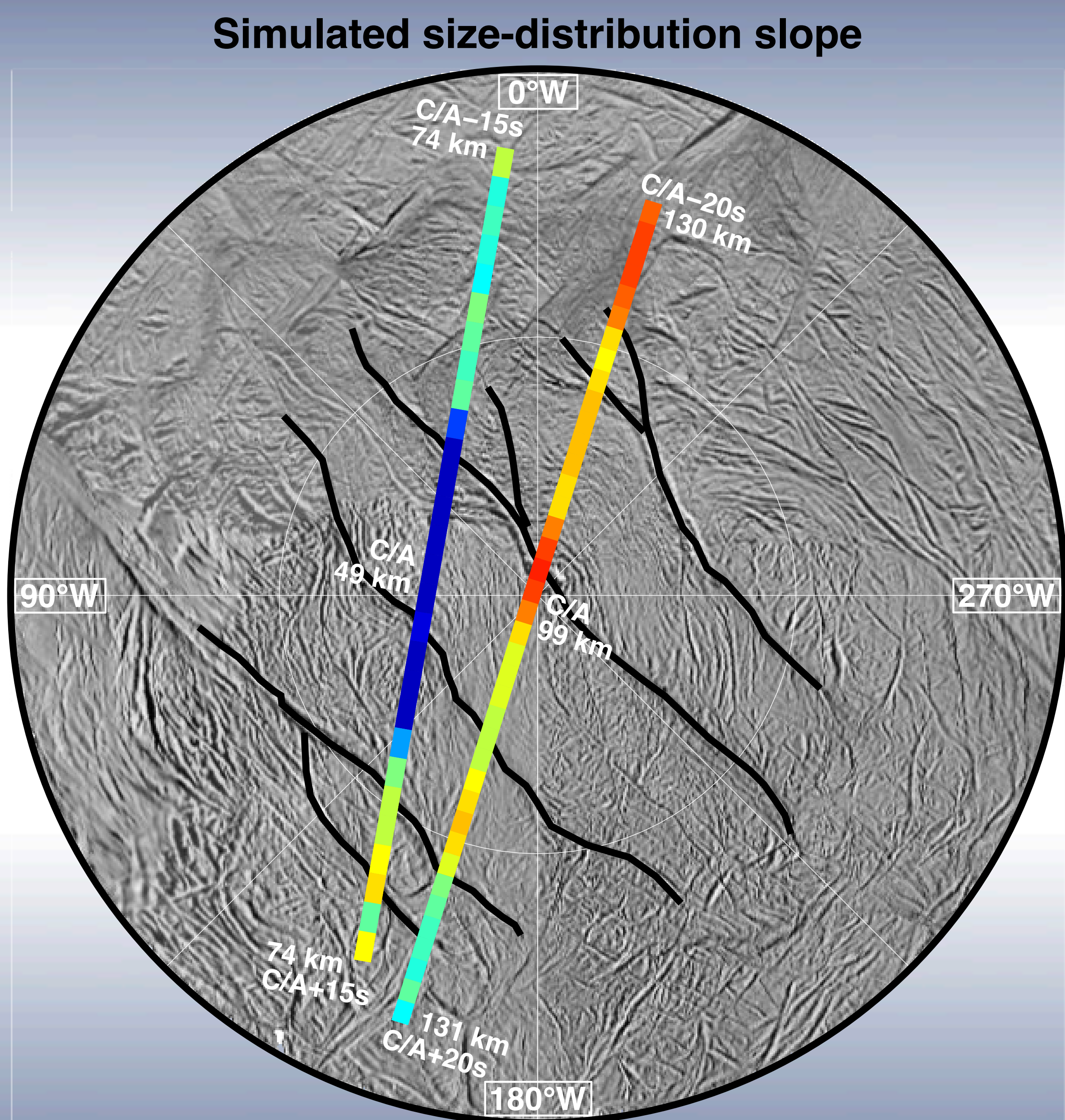
Simulated size-distribution slope

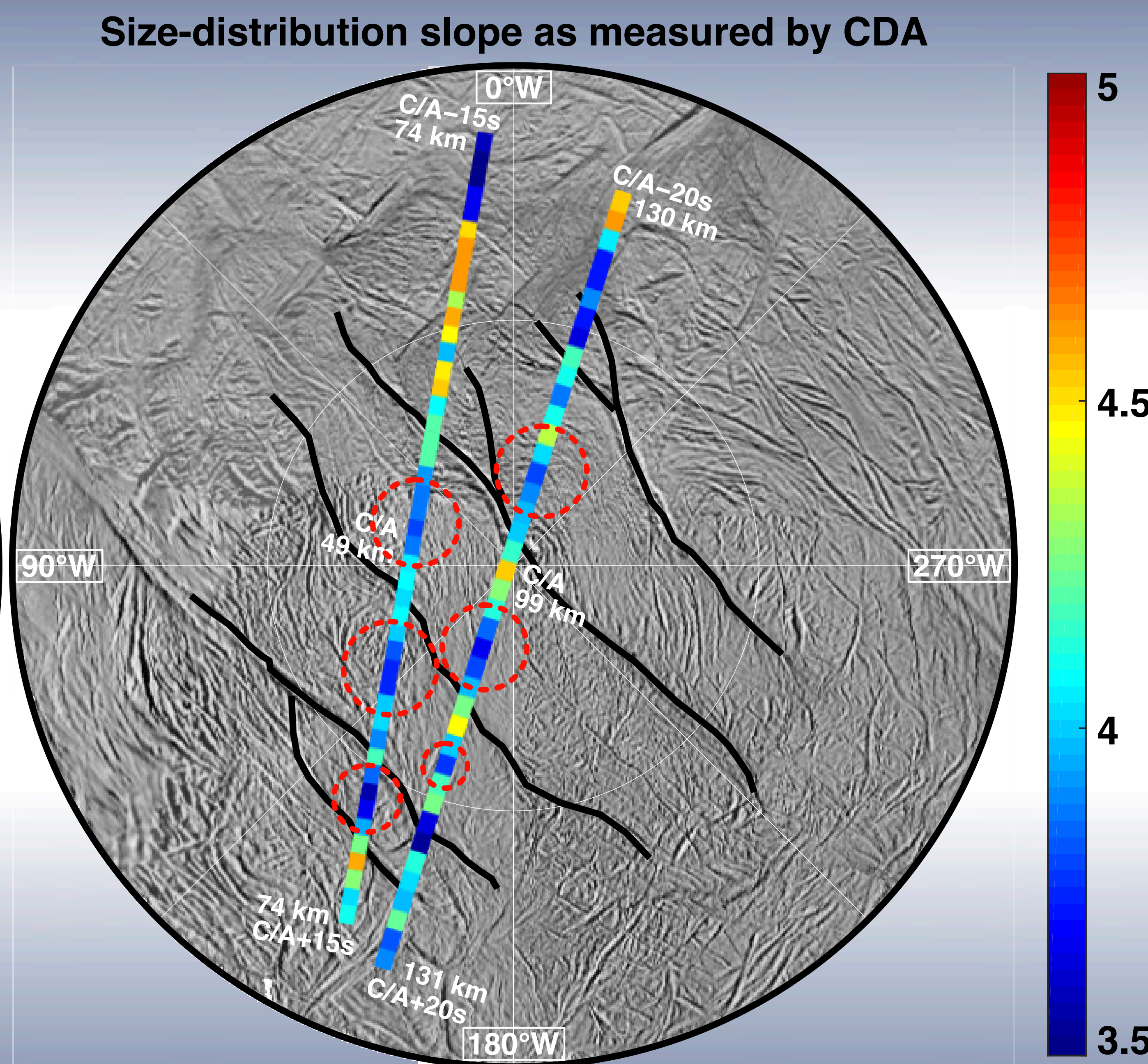


Size-distribution slope as measured by CDA



Size distribution





Speed vs. size distribution

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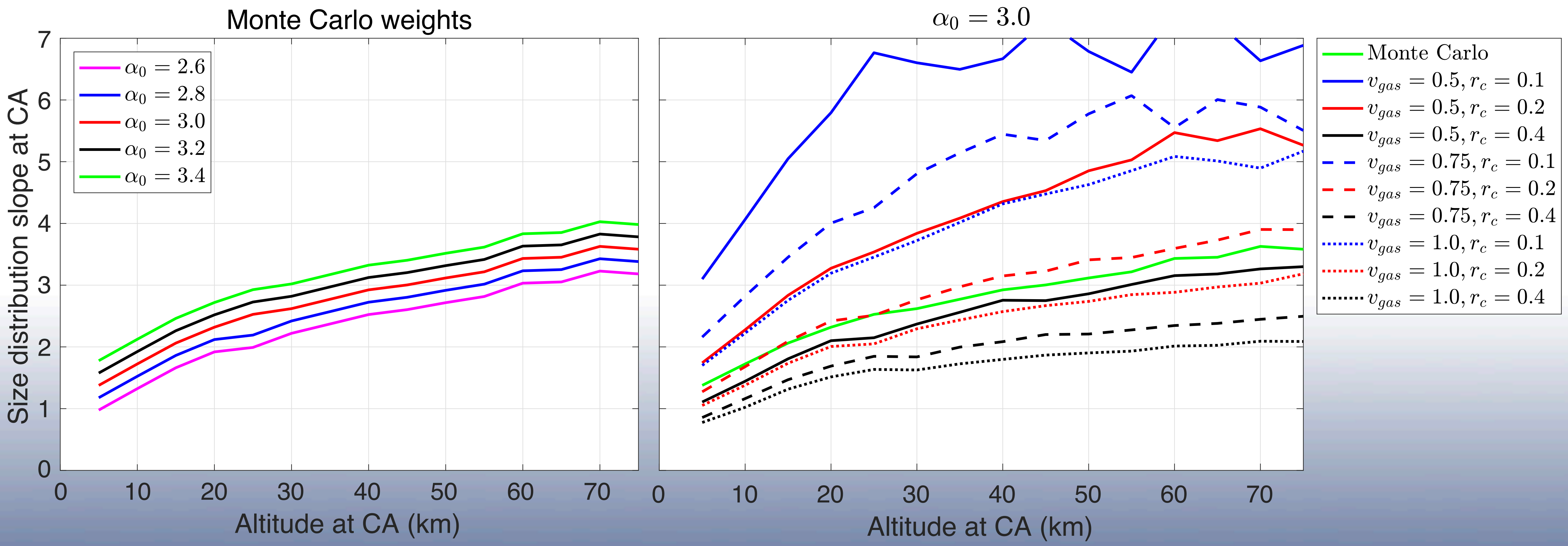

Thank you for your attention!

[1] B. S. Southworth, S. Kempf, and J. N. Spitale. Surface Deposition of the Enceladus Plume and the Angle of Emissions. *Icarus* (submitted).

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- Plumes - what, where and why?
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Why surface deposition?

Why surface deposition?

(1) How long have plumes been active?

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Competing theories of emissions

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Jets

- ~100 discrete jets proposed in Porco et al. (2014).
- Provide location and angle with respect to surface.

Competing theories of emissions

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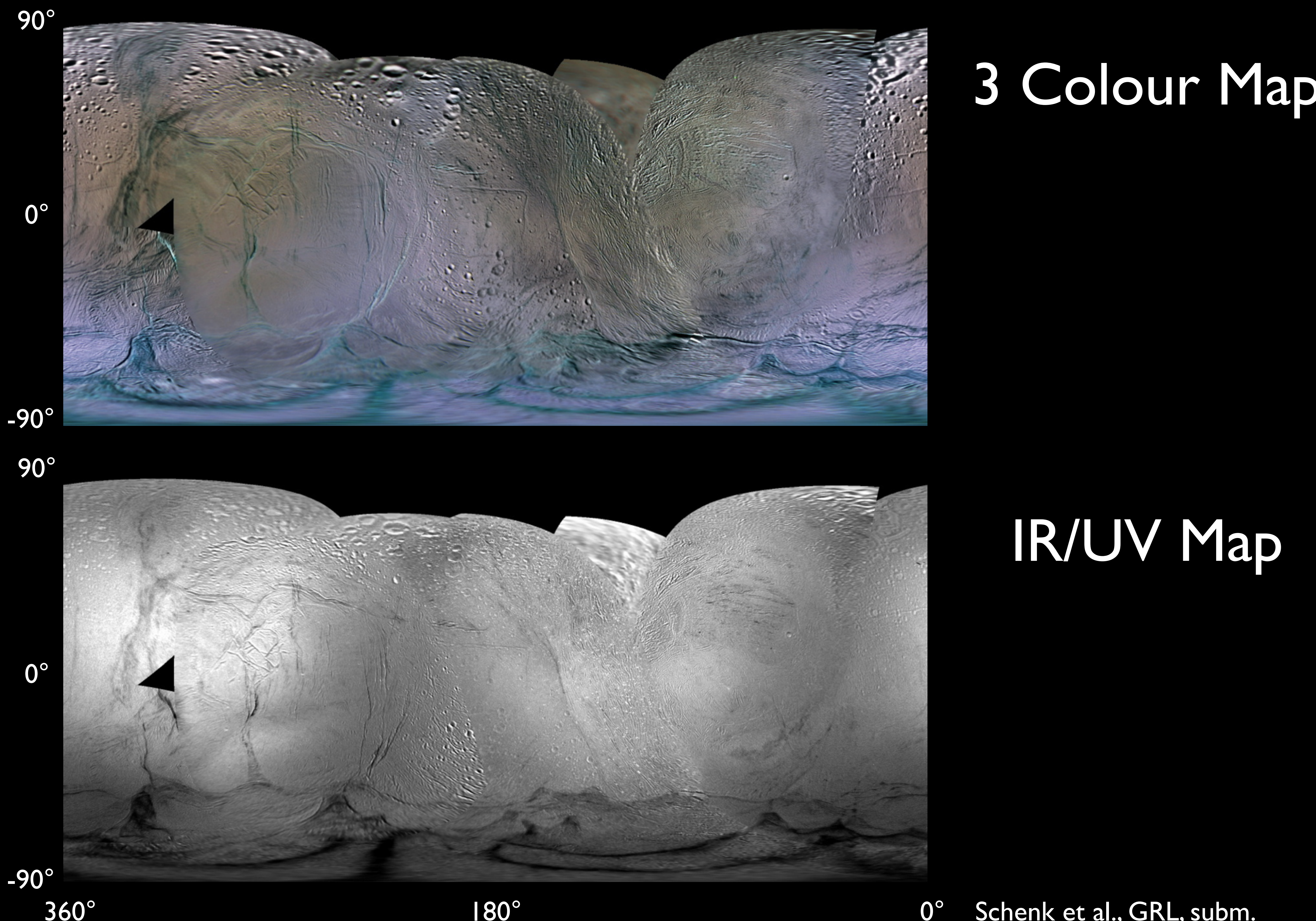
Curtain

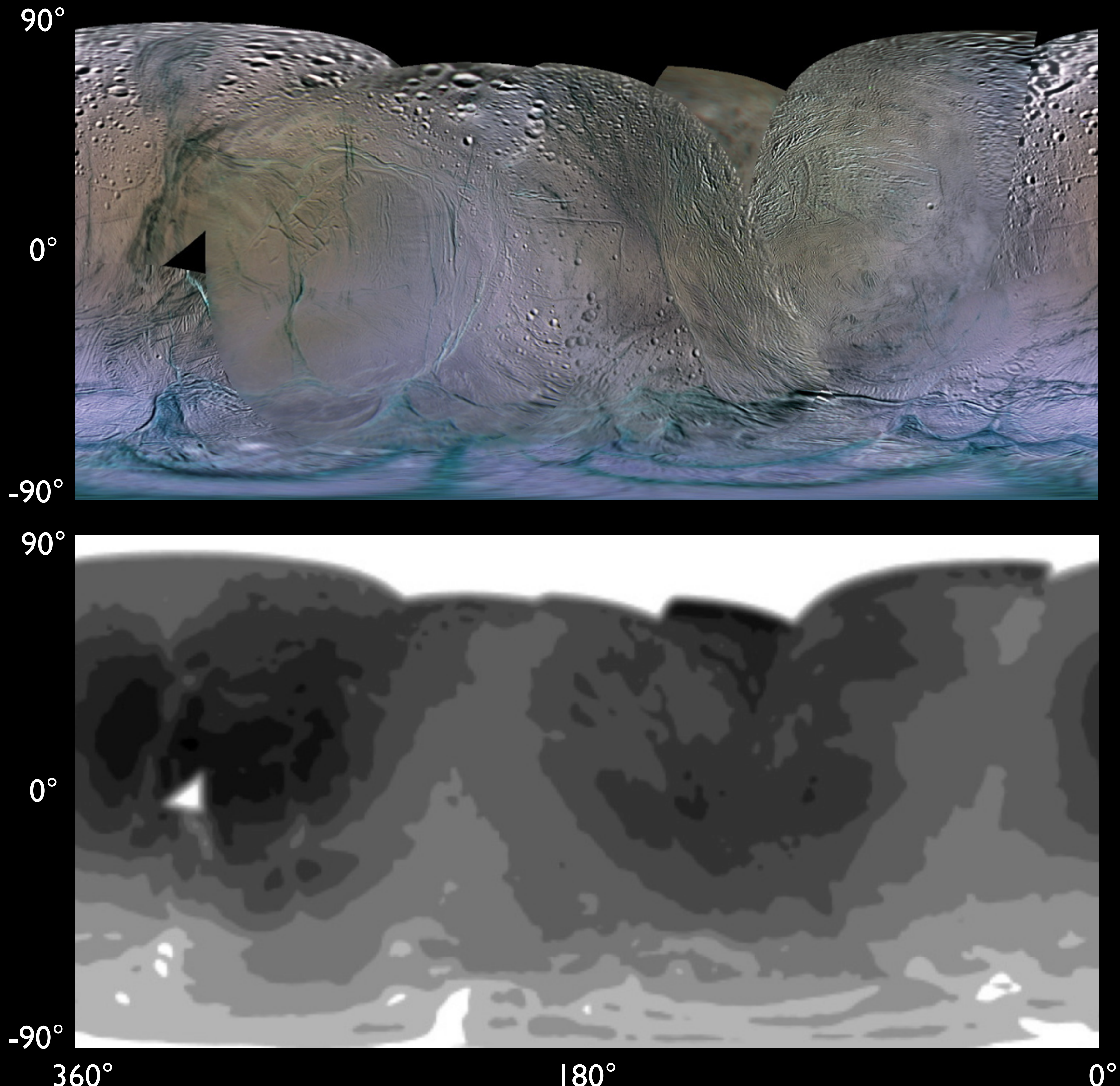
- Joseph Spitale suggested some jets formed in Porco et al. are “phantom jets.”
- Instead, plume is mostly a “curtain.”

Color maps



Schenk et al., GRL, subm.

Color maps

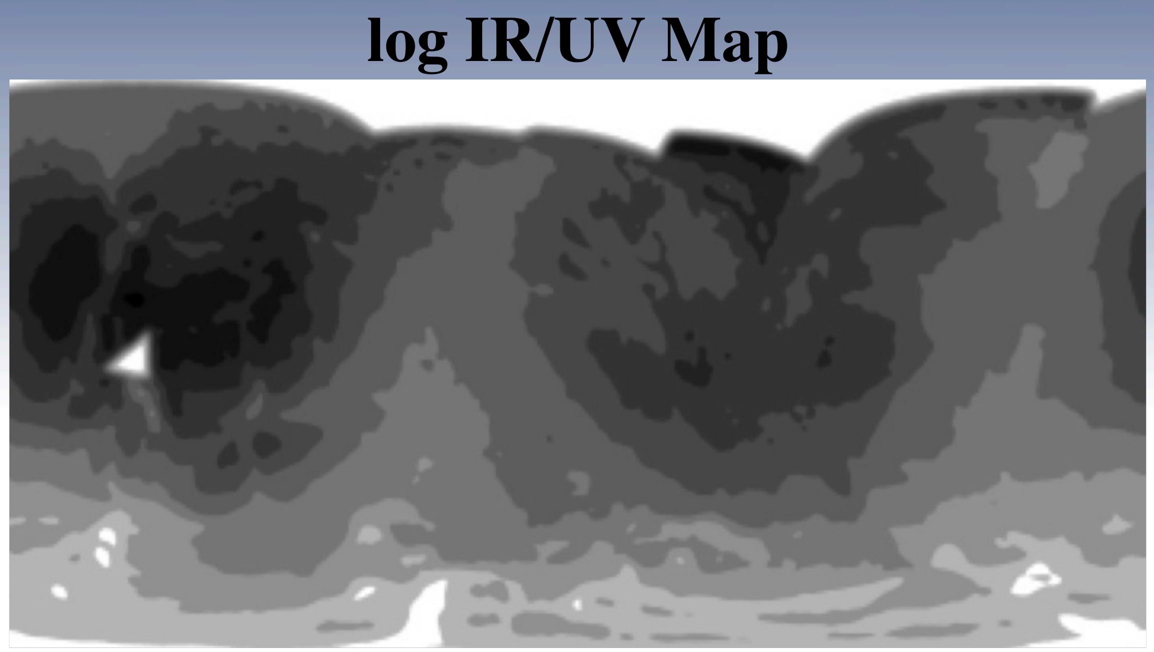


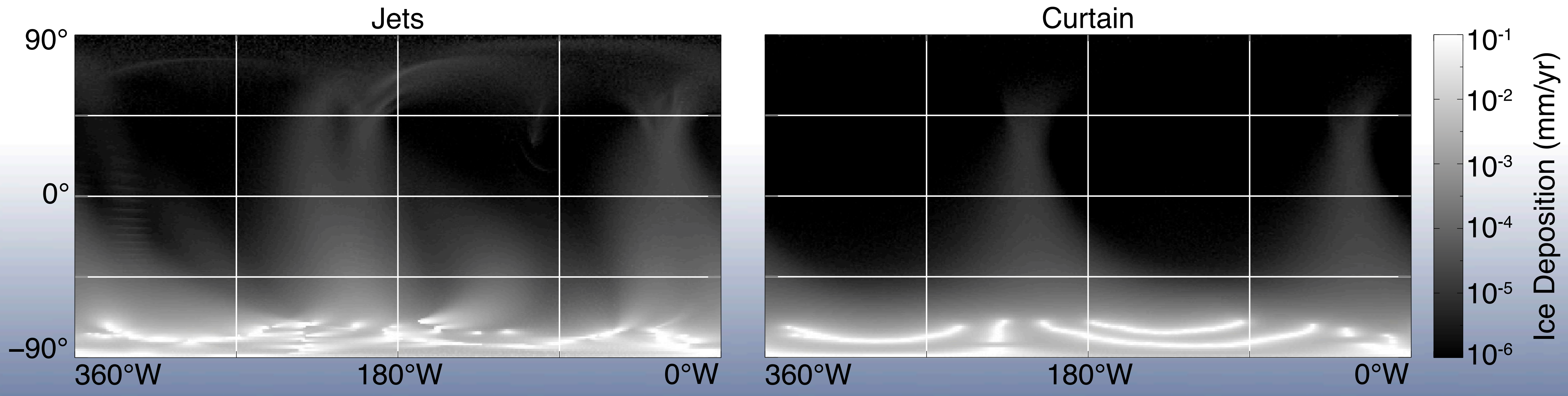
3 Colour Map

log IR/UV Map

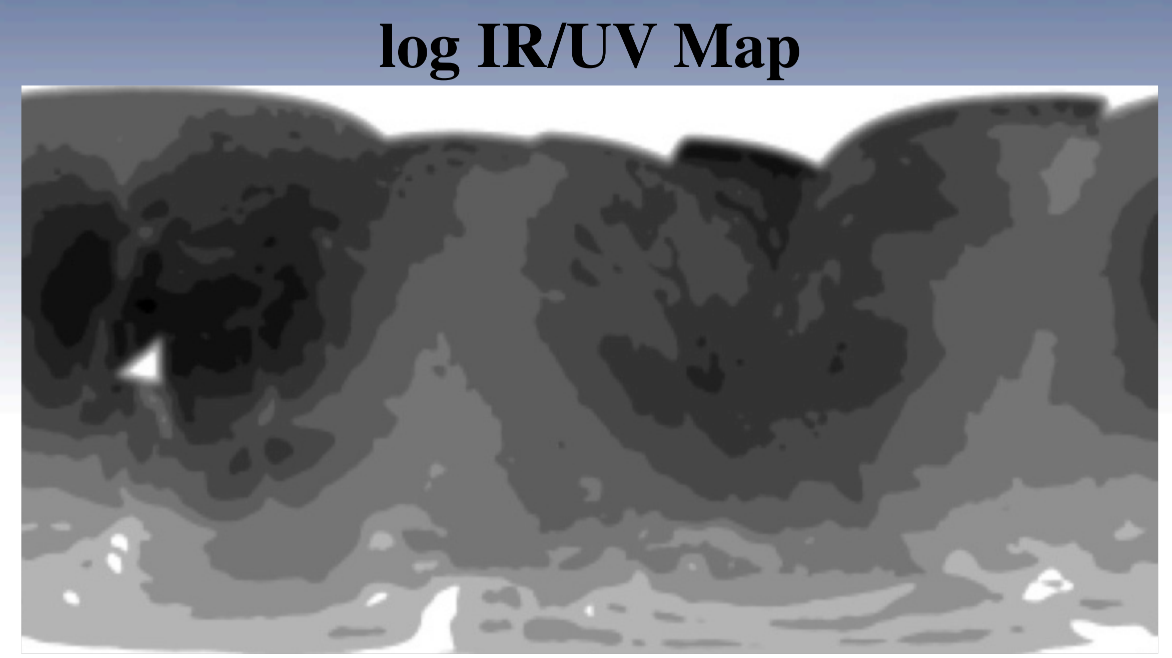
Schenk et al., GRL, subm.

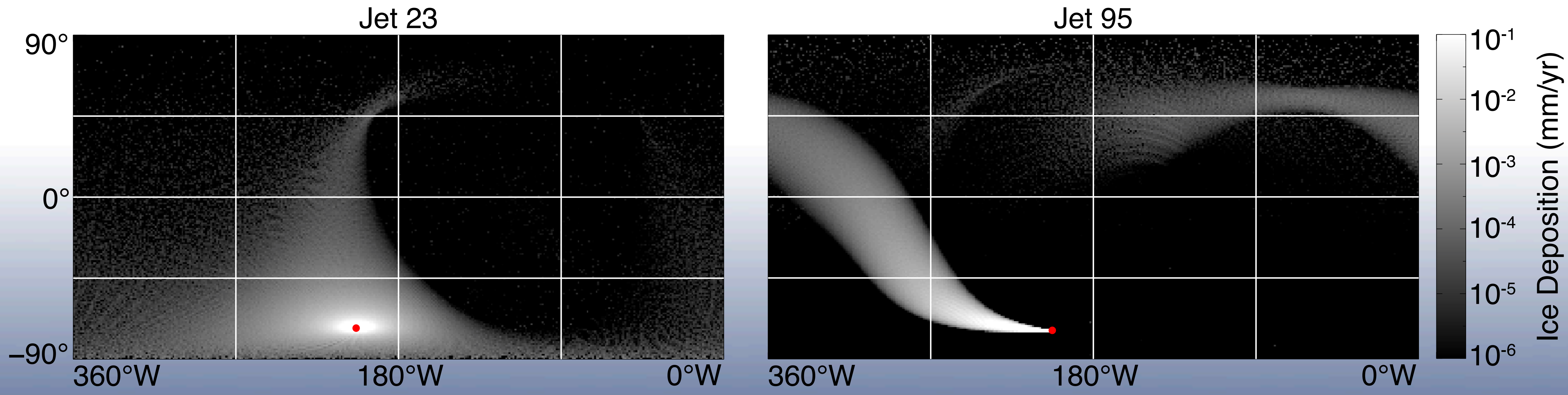
Jets vs. curtains





Effects of tilted jets





Effects of tilted jets