SWT 2019, Biarritz, Thursday, October 24th

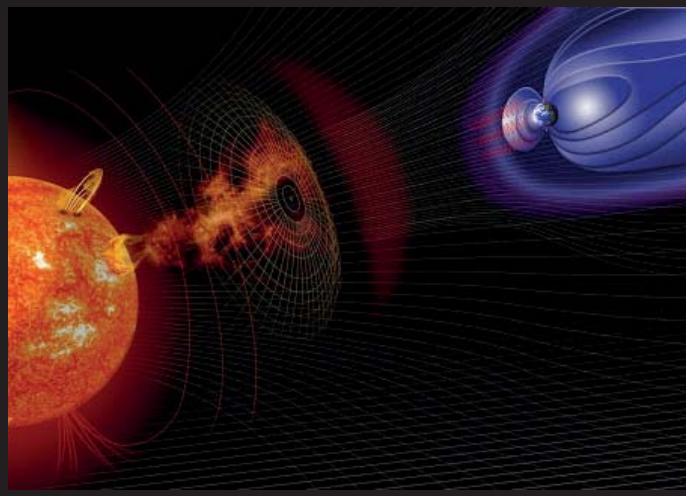
Simulation of the impact of a cold plasmaspheric plume on magnetic reconnection

Jérémy Dargent,
Nicolas Aunai, Benoît Lavraud, Sergio Toledo-Redondo & Francesco Califano

This project AIDA receives funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 776262.

Context of this study

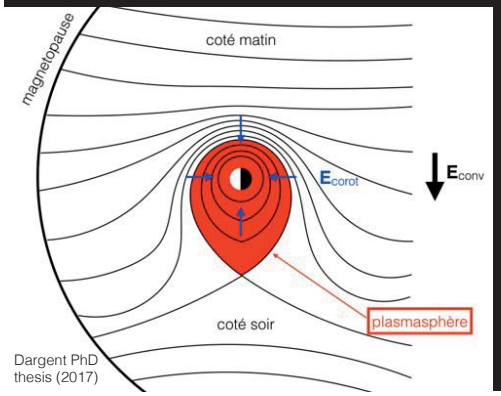
- Sun-Earth interactions
- Impact of CME on the magnetosphere
- Consequences in the magnetosphere



Context of this study

Consequences in the magnetosphere:

Formation of a **plasmaspheric plume**

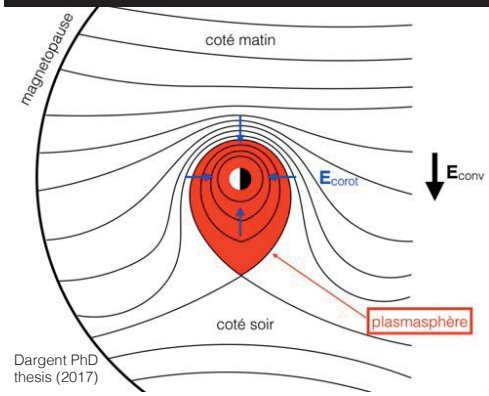


Dargent PhD thesis (2017)

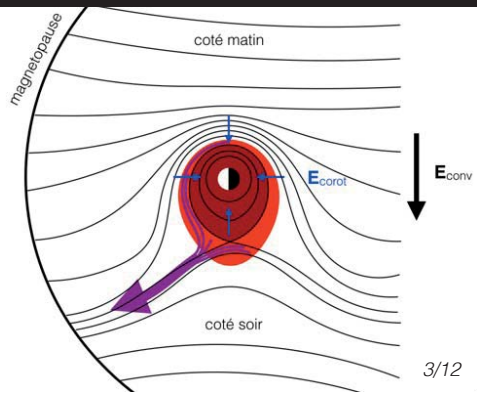
Context of this study

Consequences in the magnetosphere:

Formation of a **plasmaspheric plume**



Dargent PhD thesis (2017)



Context of this study

Consequences in the magnetosphere:

Formation of a **plasmaspheric plume**

↓

Mass loading of the magnetic reconnection (Borovski & Denton GRL 2006)

Context of this study

Consequences in the magnetosphere:

Formation of a **plasmaspheric plume**

↓

Mass loading of the magnetic reconnection (Borovski & Denton GRL 2006)

↓

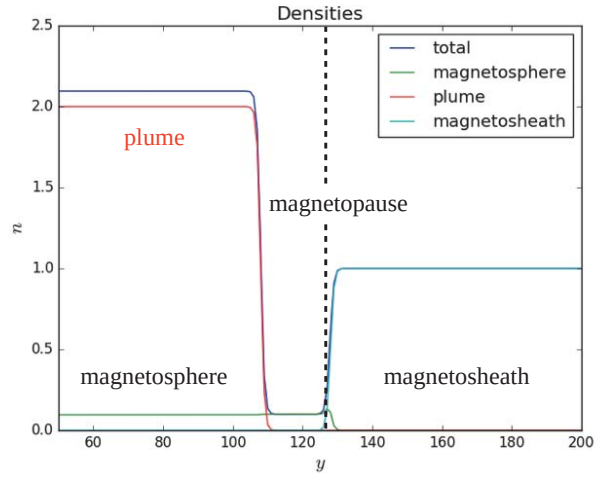
Decrease of the magnetic reconnection rate

Question

What are the **impacts of plasmaspheric plumes** on the dayside magnetopause?

In particular, how does **their low temperature** impacts magnetic reconnection?

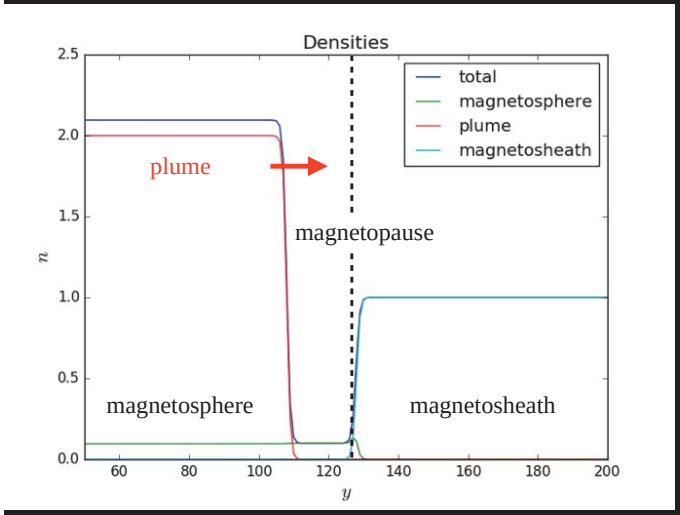
Initial setup



- One huge 2D fully kinetic simulation in three steps:
  - Reconnection without cold ions
  - Impact of the plume
  - Reconnection of the plume

$m_i/m_e = 25$ $T_e/T_i = 0.2$ $T_{hot}/T_{cold} = 500$

Initial setup

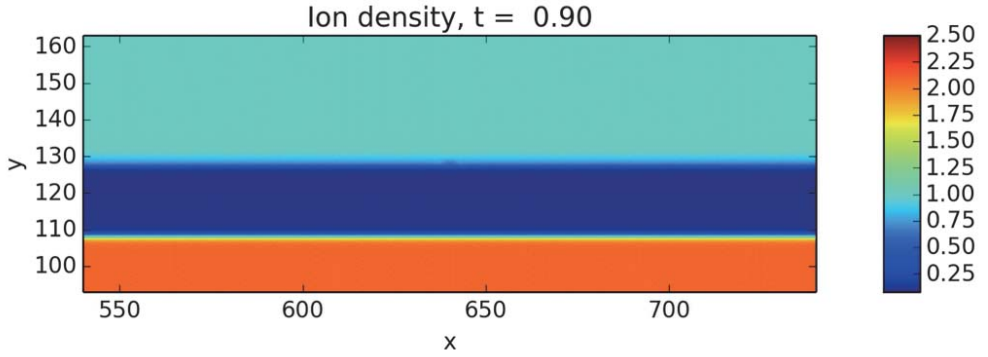


- One huge 2D fully kinetic simulation in three steps:
  - Reconnection without cold ions
  - Impact of the plume
  - Reconnection of the plume

$m_i/m_e = 25 \qquad T_e/T_i = 0.2 \qquad T_{hot}/T_{cold} = 500$

The plume simulation

Dargent et al. (in prep.)

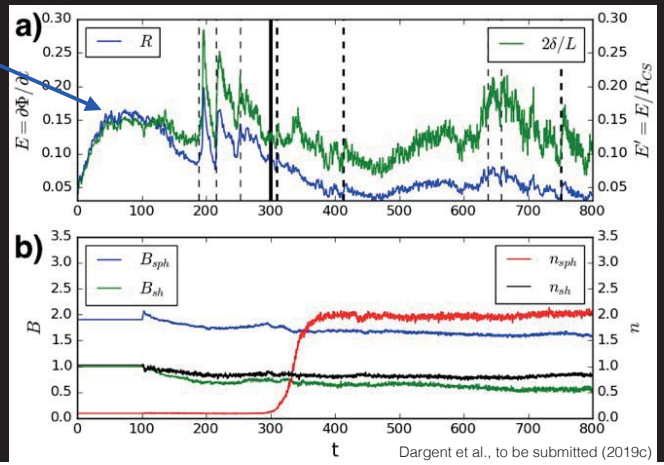


Three steps:

• Reconnection without cold ions • Impact of the plume • Reconnection of the plume

Evolution of the reconnection rate

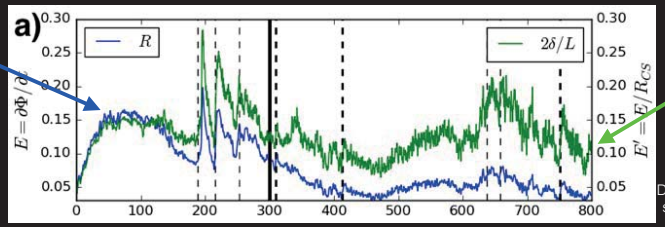
« raw » reconnection rate



Dargent et al., to be submitted (2019c)

Evolution of the reconnection rate

« raw » reconnection rate



normalized reconnection rate

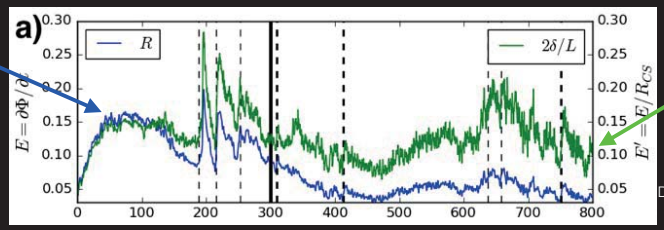
Dargent et al., to be submitted (2019c)

Normalization factor (Cassak & Shay PoP, 2007):

$$R_{CS} \sim \frac{B_1 B_2}{B_1 + B_2} \sqrt{B_1 B_2 \frac{B_1 + B_2}{B_1 n_2 + B_2 n_1}} \frac{2\delta}{L}$$

Evolution of the reconnection rate

« raw » reconnection rate



normalized reconnection rate

Dargent et al., to be submitted (2019c)

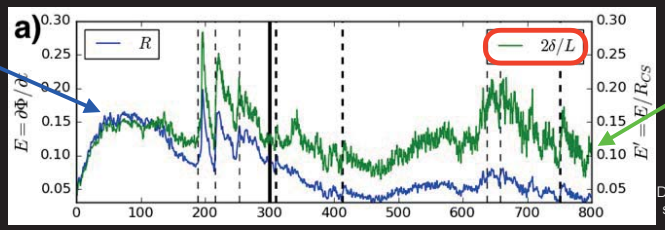
Normalization factor (Cassak & Shay PoP, 2007):

$$R_{CS} \sim \frac{B_1 B_2}{B_1 + B_2} \sqrt{B_1 B_2 \frac{B_1 + B_2}{B_1 n_2 + B_2 n_1}} \frac{2\delta}{L}$$

Normalization factor

Evolution of the reconnection rate

« raw » reconnection rate



normalized reconnection rate

Dargent et al., to be submitted (2019c)

Normalization factor (Cassak & Shay PoP, 2007):

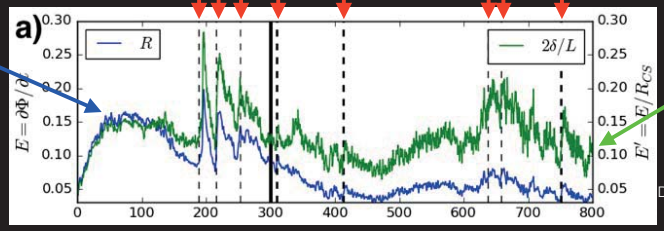
$$R_{CS} \sim \frac{B_1 B_2}{B_1 + B_2} \sqrt{B_1 B_2 \frac{B_1 + B_2}{B_1 n_2 + B_2 n_1}} \frac{2\delta}{L}$$

equivalent

Evolution of the reconnection rate

plasmoids

« raw » reconnection rate



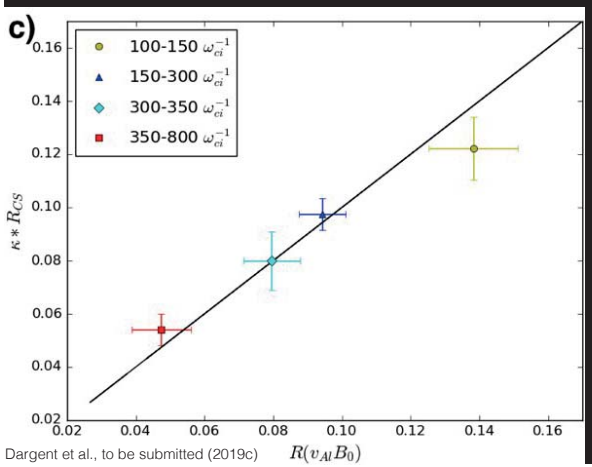
normalized reconnection rate

Dargent et al., to be submitted (2019c)

Normalization factor (Cassak & Shay PoP, 2007):

$$R_{CS} \sim \frac{B_1 B_2}{B_1 + B_2} \sqrt{B_1 B_2 \frac{B_1 + B_2}{B_1 n_2 + B_2 n_1}} \frac{2\delta}{L}$$

Evolution of the reconnection rate



Dargent et al., to be submitted (2019c)

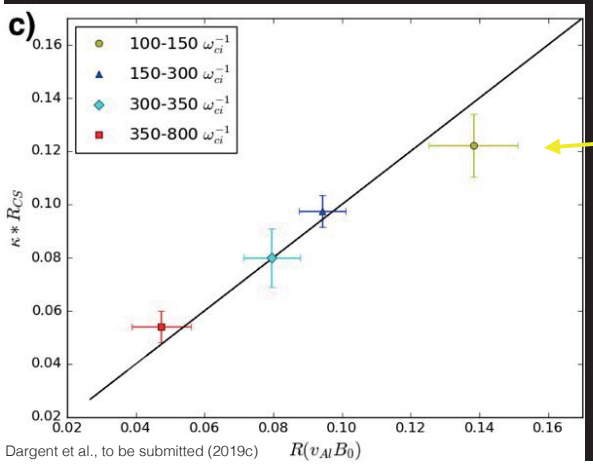
Comparison:

Reconnection rate

VS

CS scaling law

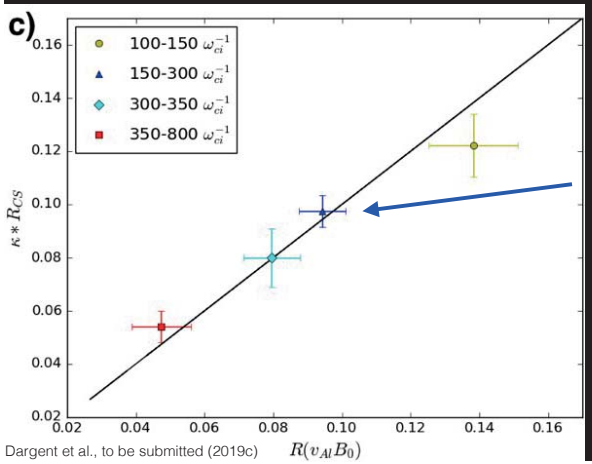
Evolution of the reconnection rate



Dargent et al., to be submitted (2019c)

Overshoot (not steady state)

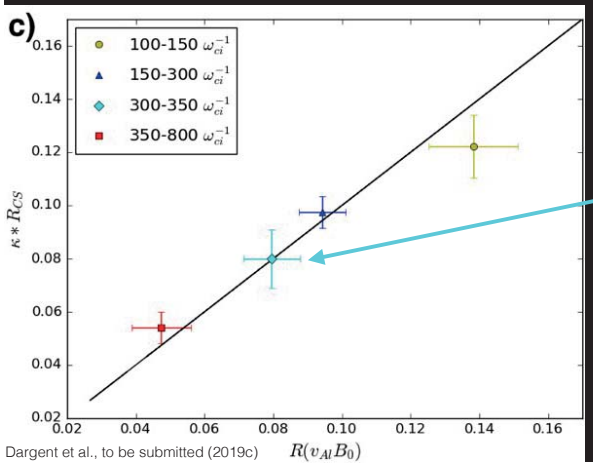
Evolution of the reconnection rate



Dargent et al., to be submitted (2019c)

Magnetic reconnection before the plume

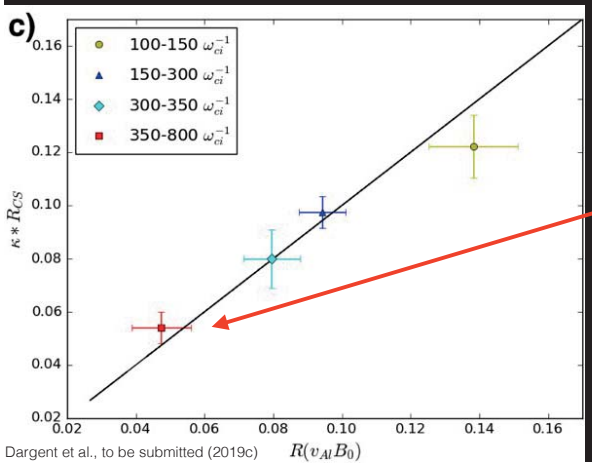
Evolution of the reconnection rate



Dargent et al., to be submitted (2019c)

Impact of the plume - transition

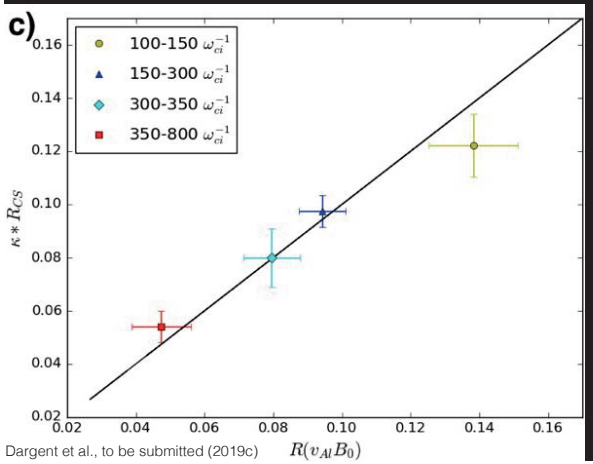
Evolution of the reconnection rate



Dargent et al., to be submitted (2019c)

Magnetic reconnection with the plume

Evolution of the reconnection rate

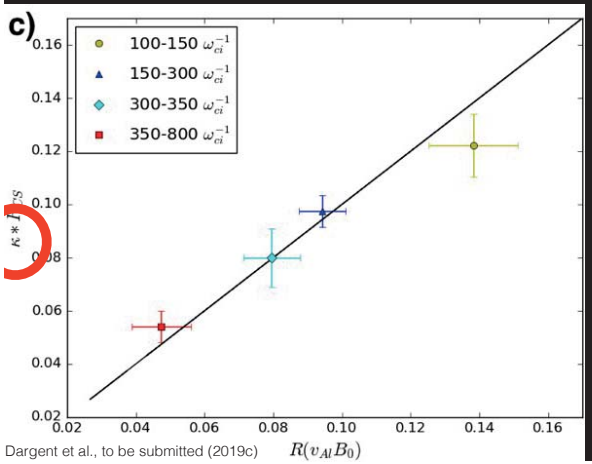


Dargent et al., to be submitted (2019c)

In average, the **normalized reconnection rate is constant**.

The temperature does not impact the reconnection rate (no kinetic effect)

Evolution of the reconnection rate



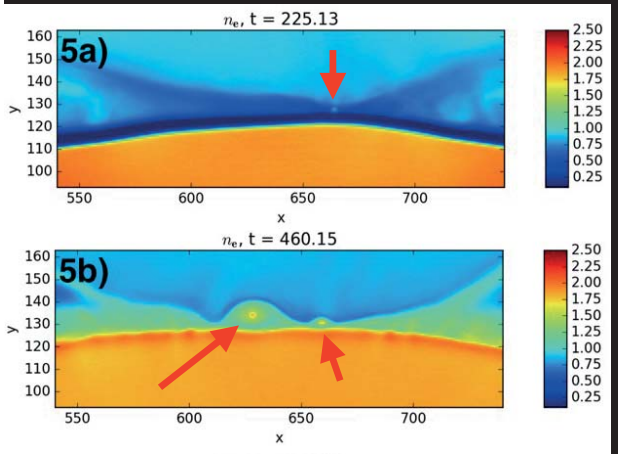
Dargent et al., to be submitted (2019c)

$\kappa = 0.127$

Consistent with Liu et al PRL (2017)

Other perspectives

What change when cold ions become dominant ?

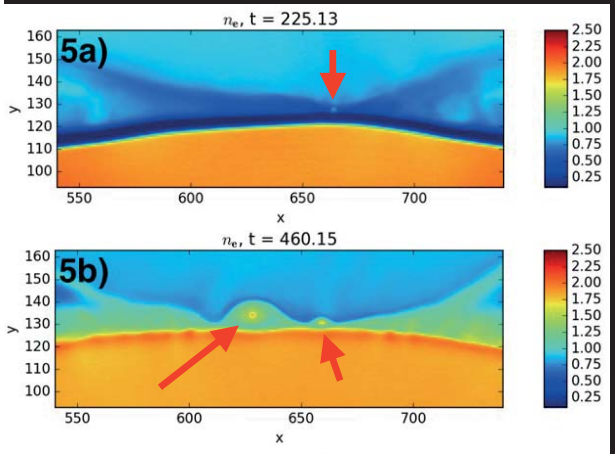


<u>Prospective:</u>
The formation of plasmoids

<u>With the plume:</u>
- bigger plasmoids
- different structure

Other perspectives

What change when cold ions become dominant ?



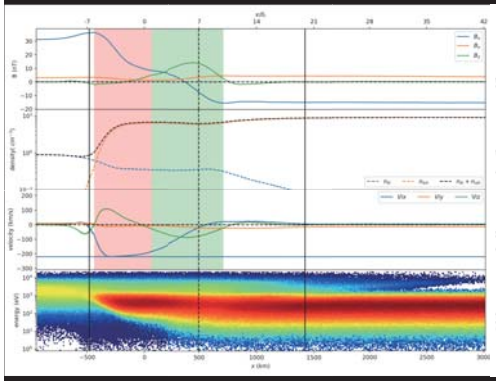
<u>Prospective:</u>
The formation of plasmoids

<u>With the plume:</u>
- bigger plasmoids
- different structure

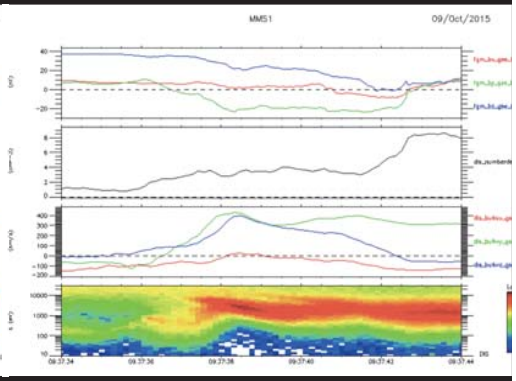
<u>Possible explanation:</u>
- jet slower
- less steady layer

Other perspectives

Virtual spacecraft observation



from the simulation



from the observations

Conclusion

- The magnetic reconnection rate is not affected by the temperature of ions.
- Other events at the magnetopause (plasmoids, waves, etc.) are affected by the plasmaspheric plume temperature.

Thank you for your attention