

# Influencia química y térmica de sprite streamers en la mesosfera terrestre

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*Solar System Departament*

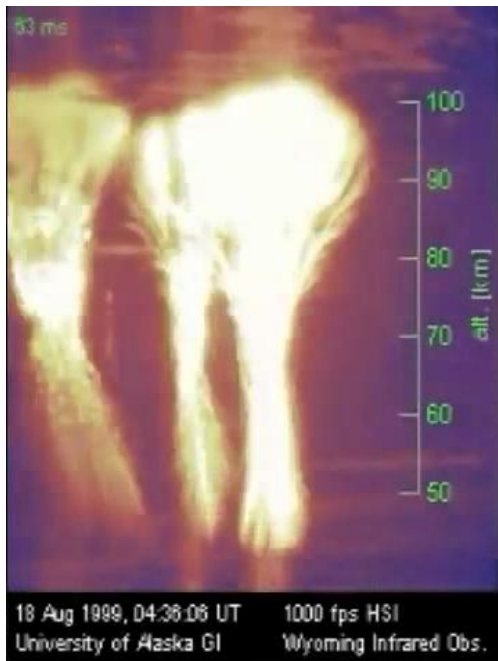
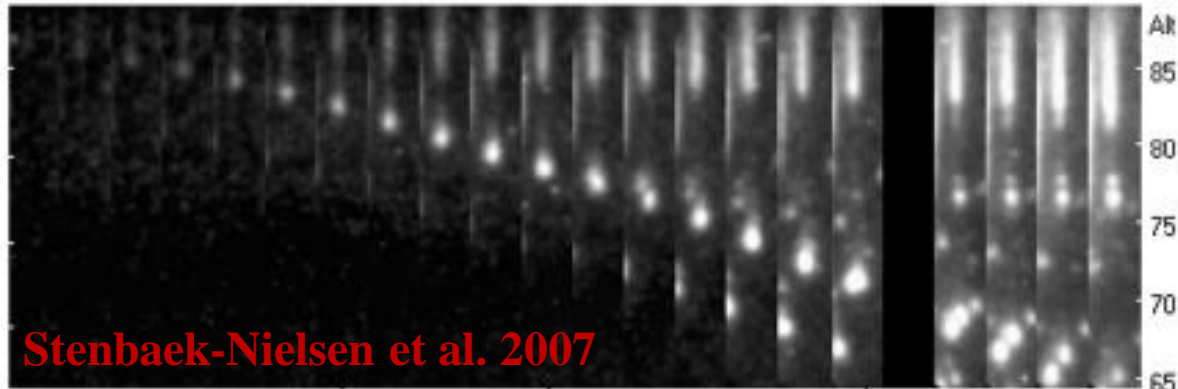
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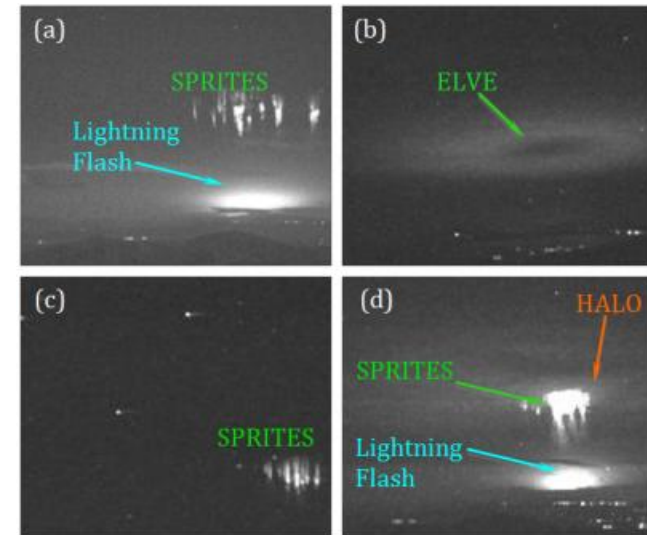
**CSIC**



# Motivación



M. Passas et al., 2014



- Estructuras de plasma filamentosa (streamers)
- Emisión óptica en rojo ( $1\text{PN}_2$ ) y en azul ( $2\text{PN}_2$ )
- Entre 40 km y 85 km
- Asociados con rayos +CG
- Diámetros superiores a 30 km
- Mecanismo de campo QE

Sentman et al. (JGR2008) → enhancement of  $10^7 \text{ cm}^{-3}$  in NO density at 70 km in sprite afterglow

Gordillo-Vázquez (JPD2008) → enhancement of  $10^6 - 10^7 \text{ cm}^{-3}$  in NO density between 63km and 78 km

Pasko et al (GRL1998) → between 50-60 km →  $\Delta T/T \sim 0.2 - 2 \%$

da Silva & Pasko (GRL2014) → fast air heating → infrasonic acoustic radiation from sprites

Komuro & Ono (JPD2014) → fast air heating → electron-impact dissociation reactions of  $\text{O}_2$  and quenching of  $\text{N}_2(\text{B,C}), \text{O}(^1\text{D})$

Picard et al. (GRL1997)

Milikh et al. (GRL1998)

→ the IR( $4.26 \mu\text{m}$ ) emission should be observable to an orbiting IR sensor

# Modelo

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## Neutras

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N, N<sub>2</sub>, O, O<sub>2</sub>, O<sub>3</sub>

NO, NO<sub>2</sub>, NO<sub>3</sub>, N<sub>2</sub>O, N<sub>2</sub>O<sub>5</sub>

CO, CO<sub>2</sub>, Ar

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## Neutras excitadas

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N<sub>2</sub>(A<sup>3</sup>Σ<sub>u</sub><sup>+</sup>, B<sup>3</sup>Π<sub>g</sub>, C<sup>3</sup>Π<sub>u</sub>, a<sup>1</sup>Π<sub>g</sub>,

a<sup>1</sup>Σ<sub>u</sub><sup>-</sup>, a<sup>''1</sup>Σ<sub>g</sub><sup>+</sup>, B<sup>'3</sup>Σ<sub>u</sub><sup>-</sup>, E<sup>3</sup>Σ<sub>g</sub><sup>+</sup>,

W<sup>3</sup>Δ<sub>u</sub>, w<sup>1</sup>Δ<sub>u</sub>), O<sub>2</sub>(a<sup>1</sup>Δ<sub>g</sub>, b<sup>1</sup>Σ<sub>g</sub><sup>+</sup>,

4.5eV), O(<sup>1</sup>D, <sup>1</sup>S), NO(A<sup>2</sup>Σ<sup>+</sup>)

N(<sup>2</sup>D, <sup>2</sup>P), Ar(<sup>3</sup>P), N<sub>2</sub>(rot), O<sub>2</sub>(rot)

N<sub>2</sub>(v=1,...,8), O<sub>2</sub>(v=1,...,4)

CO<sub>2</sub>(v<sub>1</sub>, v<sub>2</sub><sup>1</sup>, v<sub>3</sub>)

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## Iones negativos

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e<sup>-</sup>, O<sup>-</sup>, O<sub>2</sub><sup>-</sup>, O<sub>3</sub><sup>-</sup>

NO<sup>-</sup>, NO<sub>2</sub><sup>-</sup>, NO<sub>3</sub><sup>-</sup>, N<sub>2</sub>O<sup>-</sup>

CO<sub>3</sub><sup>-</sup>

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## Iones positivos

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N<sup>+</sup>, N<sub>2</sub><sup>+</sup>, N<sub>2</sub><sup>+</sup>(A<sup>2</sup>Π<sub>u</sub>, B<sup>2</sup>Σ<sub>u</sub><sup>+</sup>)

N<sub>3</sub><sup>+</sup>, N<sub>4</sub><sup>+</sup>, O<sup>+</sup>, O<sub>2</sub><sup>+</sup>, O<sub>4</sub><sup>+</sup>

NO<sup>+</sup>, NO<sub>2</sub><sup>+</sup>, N<sub>2</sub>O<sup>+</sup>, N<sub>2</sub>O<sub>2</sub><sup>+</sup>

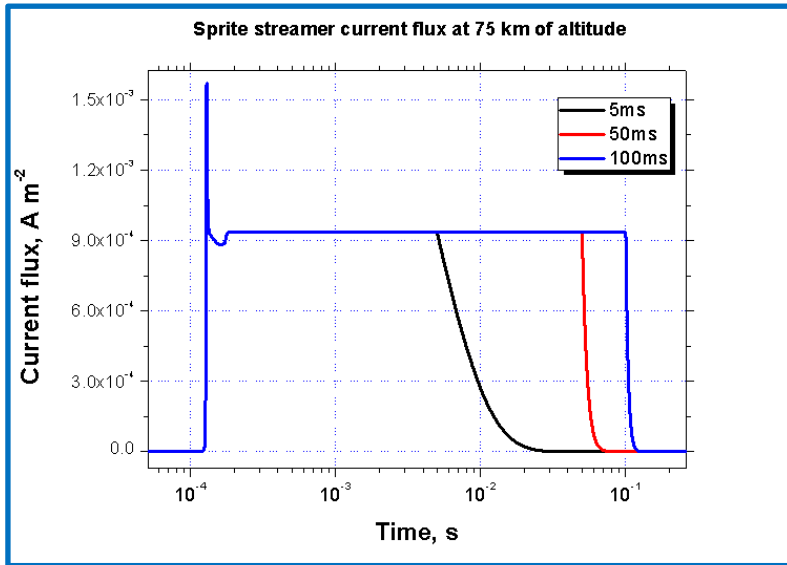
Ar<sup>+</sup>

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**...y mas de 900 procesos incluyendo, VT, VV, impacto electrónico, quenching,...**

Parra-Rojas et al., JGR-Space Physics, 2015

# Modelo autoconsistente....



Luque *et al.*, JPhD, 2008  
 Luque and Ebert, GRL, 2010

$$\frac{\partial n_i}{\partial t} = G_i - L_i$$

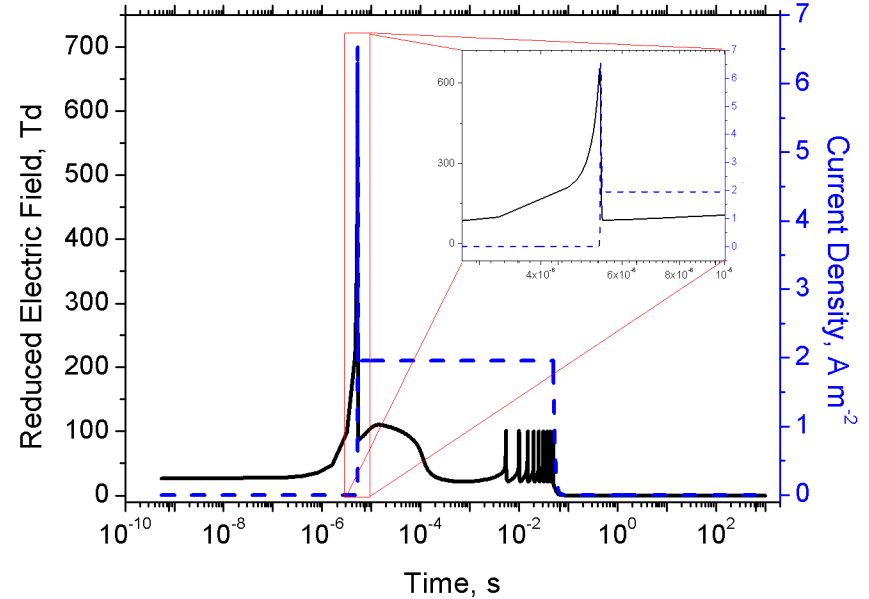
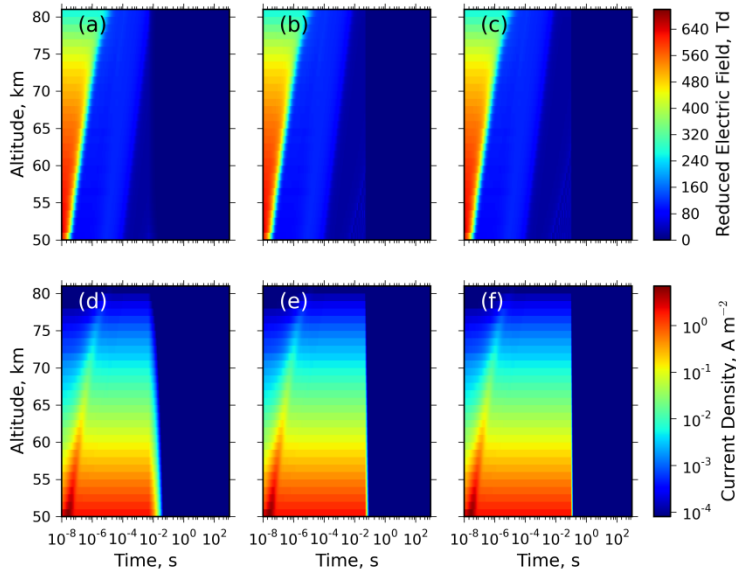
$$E = \sigma J$$

$$P_{gas} = P_{ext} + P_{abs} - P_{elec} - P_{chem} - P_{rad}$$

$$\frac{e\mathbf{E}(t)}{m_e} \nabla_{\mathbf{v}} f(\mathbf{v}, t) = \left( \frac{\partial f}{\partial t} \right)_{collisions}$$

# Resultados

Reduced electric field and current density



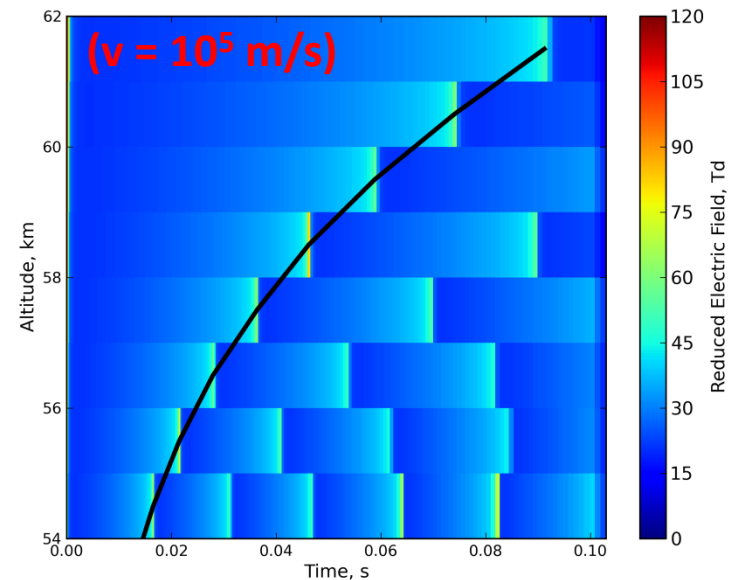
1. Desactivación de AD



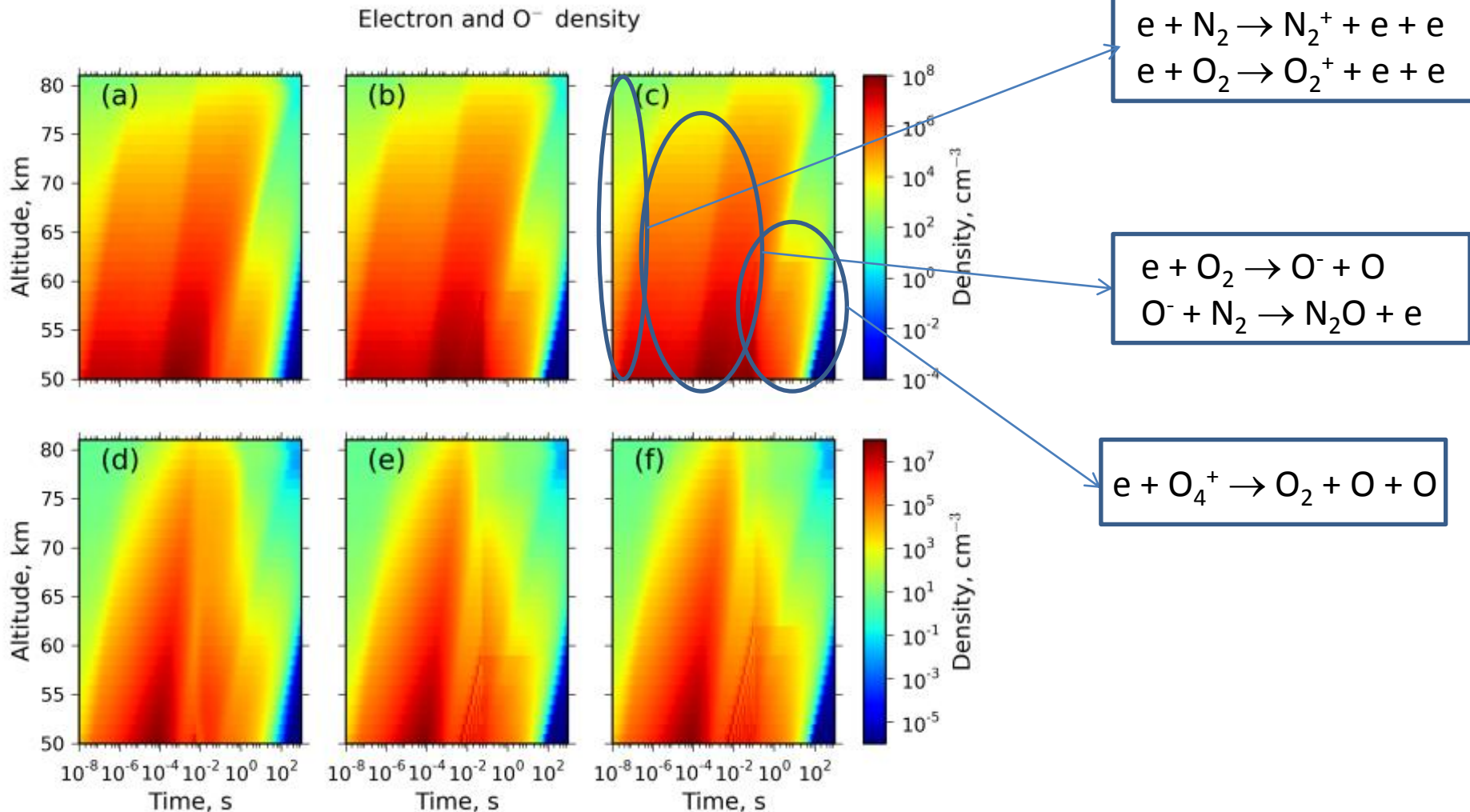
2. Electrones perdidos por



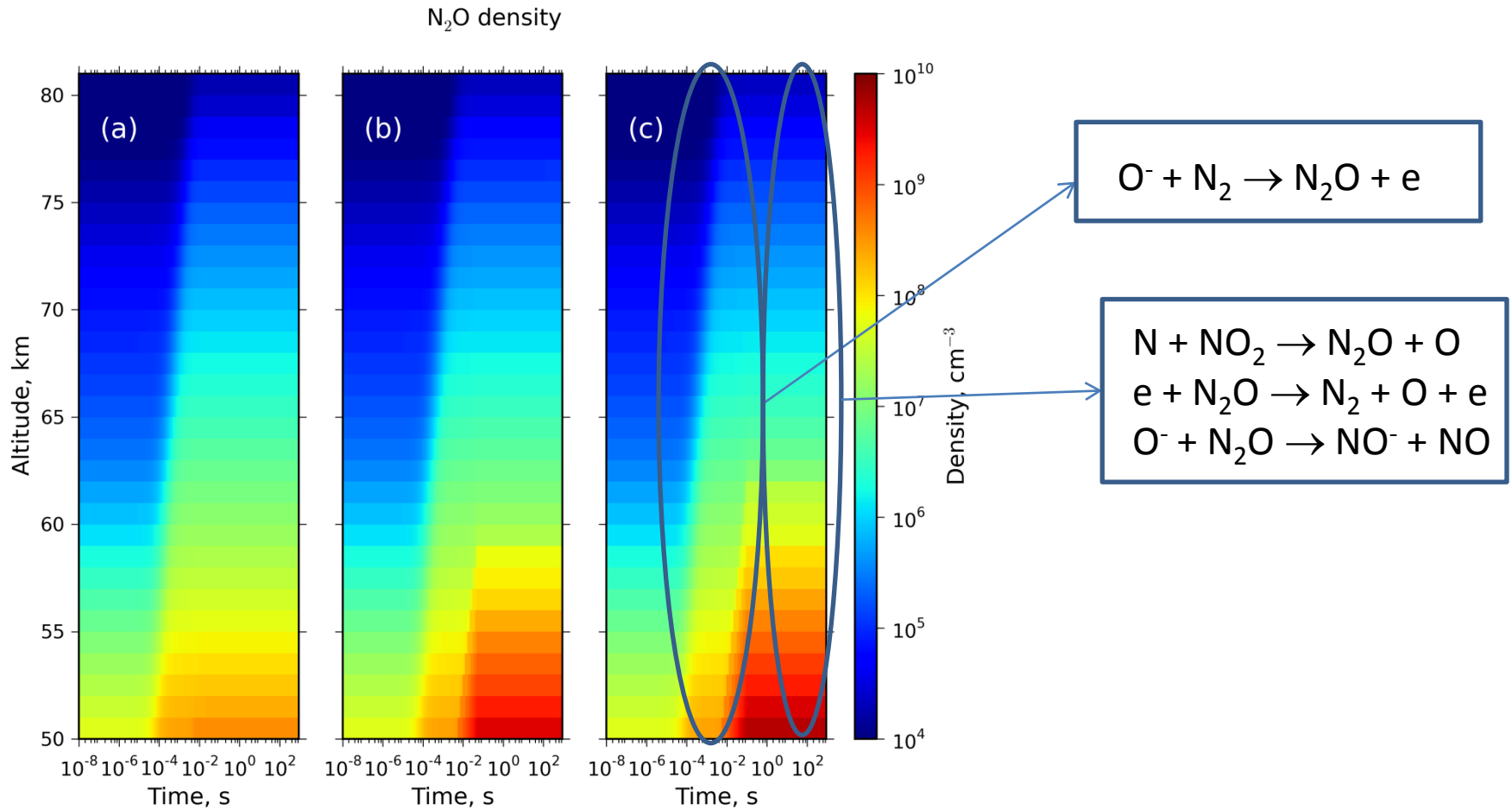
3. E/N aumenta se activa el AD



# Un gran impacto en todas las especies



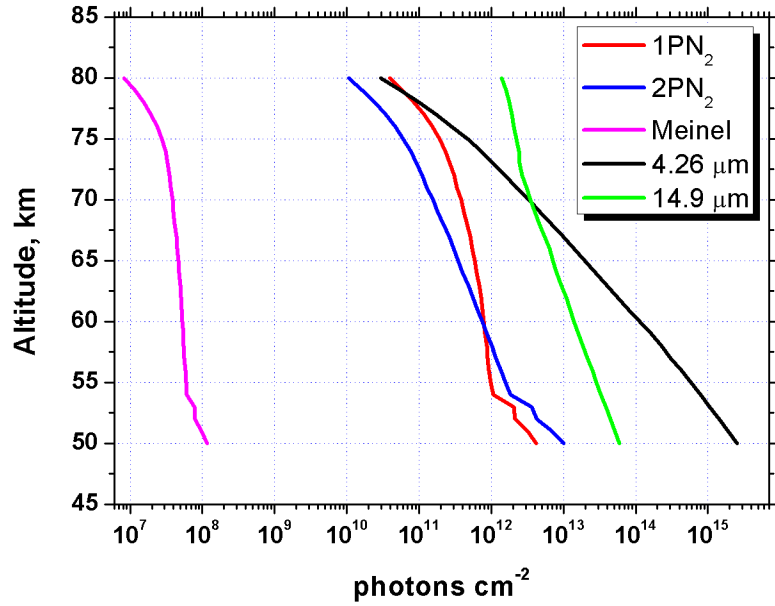
# Gas de efecto invernadero



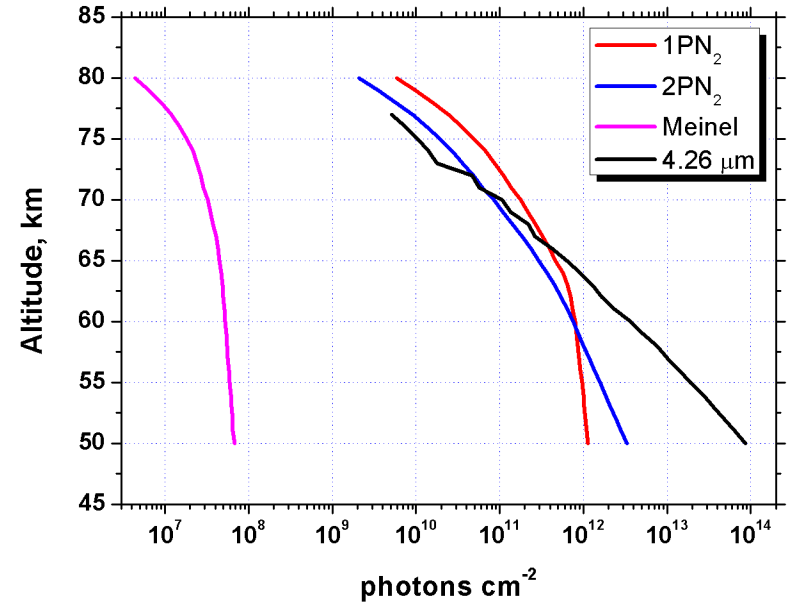


# Brillos integrados

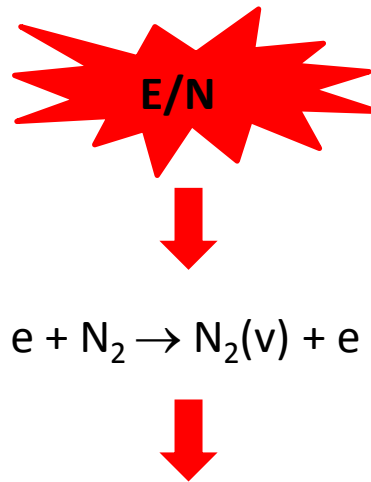
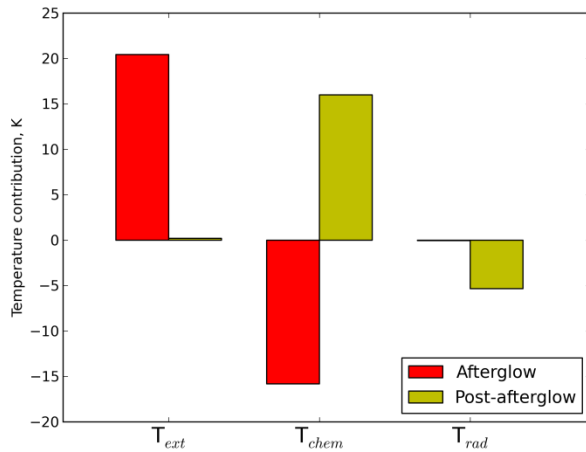
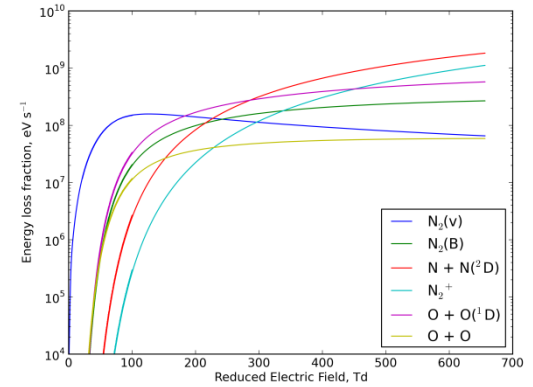
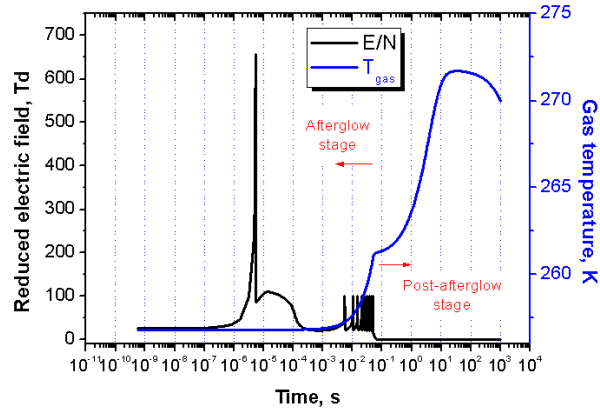
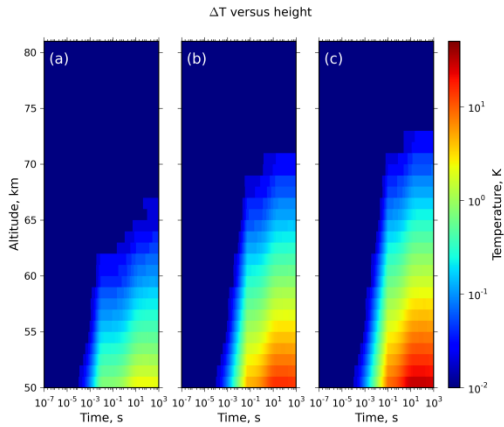
33 fps



1000 fps



# Efectos térmicos

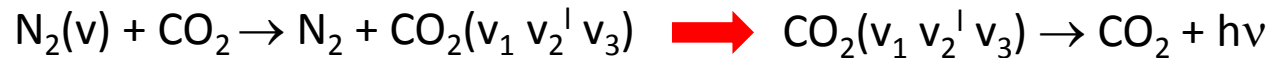


$\Delta T/T(100 \text{ ms}) \sim 11 \%$

$\Delta T/T(50 \text{ ms}) \sim 6 \%$

$\Delta T/T(5 \text{ ms}) \sim 0.9 \%$

$\Delta T/T \sim 0.2-2 \%$   
(Pasko *et al.* GRL 1998)



# Conclusiones



Los sprite streamers tienen un gran impacto en la química atmosférica, especialmente en especies como  $\text{NO}_x$  y  $\text{N}_2\text{O}$  las cuales pueden afectar a la densidad del ozono.



La emisión infrarroja en las bandas  $4.23 \mu\text{m}$  y  $14.9 \mu\text{m}$  podría ser detectada desde el espacio con la instrumentación adecuada



El calentamiento de la atmósfera producido por un sprite streamer es proporcional a la duración de la corriente de afterglow y es más intenso a bajas altitudes. La mayoría de la energía del campo eléctrico se emplea en la excitación del  $\text{N}_2(\text{v})$ .

# THANKS FOR YOUR ATTENTION!!!



Mas información en...

Parra-Rojas *et al.* JGR-Space Physics, 118, 1–25, doi:10.1002/jgra.50449, 2013

Parra-Rojas *et al.* JGR-Space Physics, Accepted 2015