Didier LEBRUN , LPSC
Journee Astroparticules
CNRS, 7Septembre 2007

Astroparticules/Geosciences : l' Atmosphere

Role des Rayons Cosmiques ⟷ Role de l'Atmosphere

Exemples

- **Surveillance Atmospherique dans les Observatoires de Rayons Cosmiques**
  - *L atmosphere comme detecteur impose un controle adequat*
  - *Cela a conduit a construire de veritables Observatoires Atmospheriques*
- **Orages de Haute et Basse Atmosphere**
  - *Sprites, Elves, Blue jets, TGRB et autres phenomenes de la haute atmosphere sont ils declenches par les RC ?*
  - *Des Orages du type "RadioBurst" peuvent-ils constituer un nouveau type de detection des RCUHE ?*
- **"Cosmo-Climatologie"**
  - *Y-a-t'il vraiment une forte contribution du rayonnement cosmique galactique au Rechauffement Climatique ?*

EAS et Atmosphere

- Parametres atmospheriques intervenant dans la detection de Rayons Cosmiques et ayant une influence significative sur la mesure .

➢ *Au-dela des conditions meteorologiques locales affectant le fonctionnement des detecteurs eux-meme, un controle precis de ces parametres atmospheriques dans un volume de detection superieur a 10^4 km^3, est indispensable*

Gerbe Atmospherique (EAS)

- **Developpement**
  - **Profil, Max., p (sol)…**
- **Production de photons (UV)**
  - **Fluorescence (*Yield,Quenching*)**
  - **Cerenkov *(n (z))***
- **Attenuation lumiere**
  - **Extinction**
  - **Diffusion**
- ***Autres selon detection***
  - ***Bruit lumineux***
  - ***Radio***
  - ***Detection Spatiale***

Variables Atmospheriques

- **thermodynamiques**
  - **P,T,H … sol + Profils (z)**
- **Transfert Radiatif**
  - **Indice**
  - **Contenu Moleculaire**
    - **O_3, Vapeur d eau**
  - **Aerosols**
    - **Type, phase**
  - **Nuages**
- ***Autres parametres***
  - ***Airglow***
  - ***Atm. Electrique (radio)***
  - ***Albedo , Inter. Air-Ocean***

Troposphere
Sratosphere
Ionosphere
Mesosphere

Impact de la Physique de l'atmosphere

- **Outils de simulation**
  - **Utilisation des modeles d'Atmosphere**
    - *Thermodynamique (stationnaires : US-STD76, CIRA86…)*
    - *Transfert Radiatif (LOWTRAN, MODTRAN…)*

- **Outils de calibration et de controle**
  - **Instruments de la Physique de l'Atmosphere**
    - *(meteo, radiosondes, LIDAR…)*

- **Surveillance Atmospherique**
  - *La variabilite locale et temporelle des conditions atmospheriques ont impose la realisation de veritables*

Observatoires Atmospheriques Associes

Atmospheric Monitoring
Observatoire Pierre Auger

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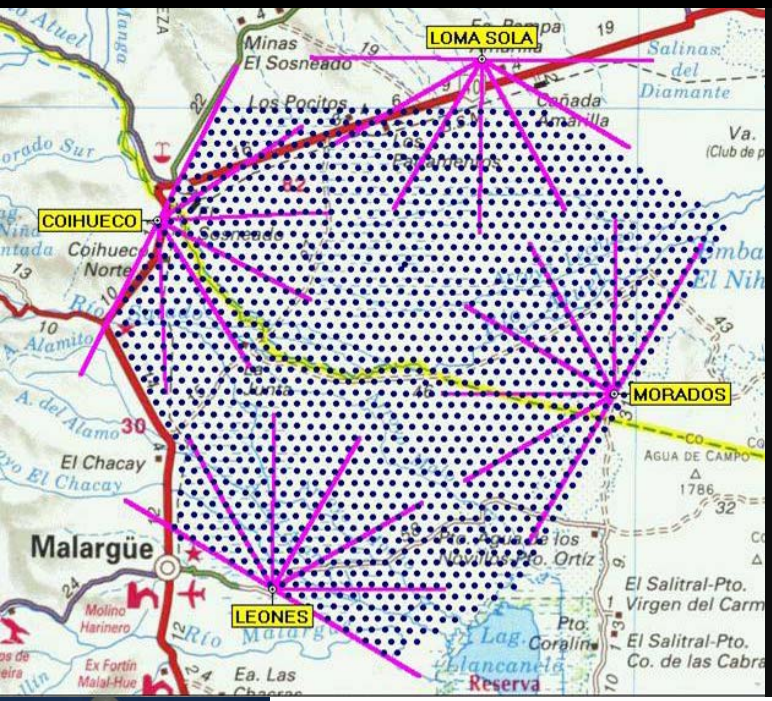
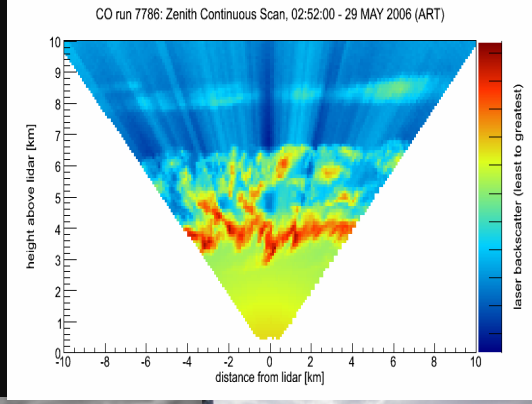
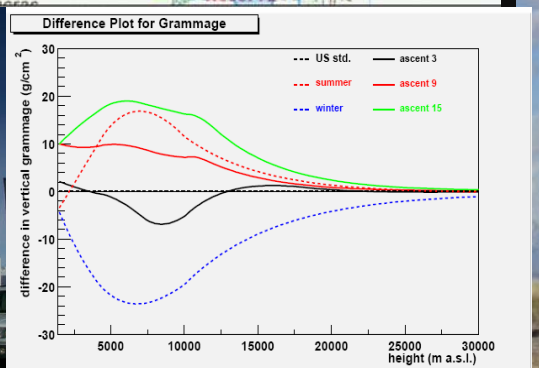
3000 km² sous surveillance atmospherique quasi continue

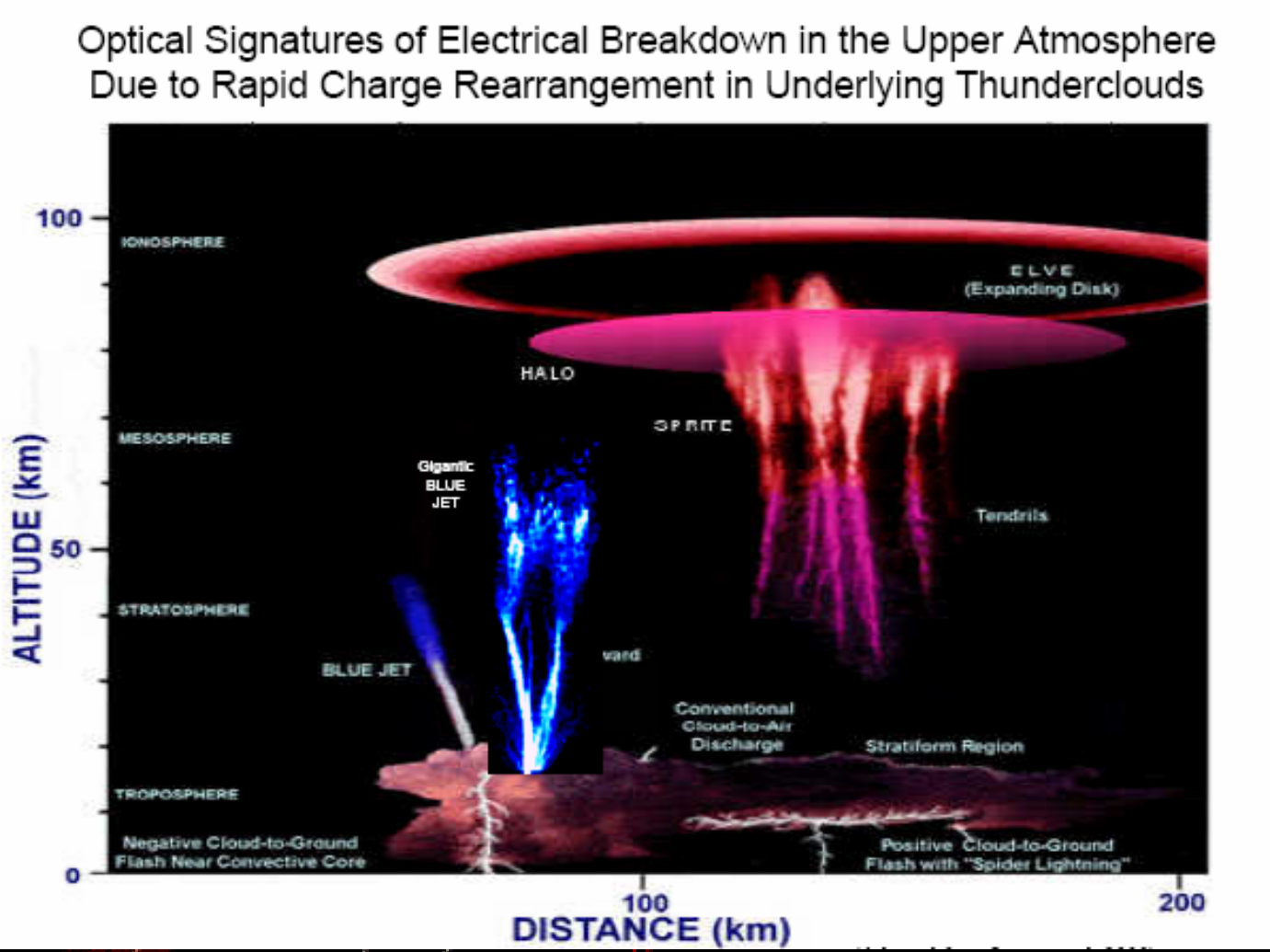


- **Sur chaque site de telescope**
  - *Station meteo*
  - LIDAR elastique pointable
  - LIDAR Raman (1)
  - Camera IR Nuages
  - APFM Aerosols
  - HALM (*Attenuation horizontale*)
  - FRAM (*Extinction etoiles*)
- CLF (Laser central)
  - *(calibration et 'side'-LIDAR)*
- BLF (Ballons)
  - *Meteo et Radiosondes*

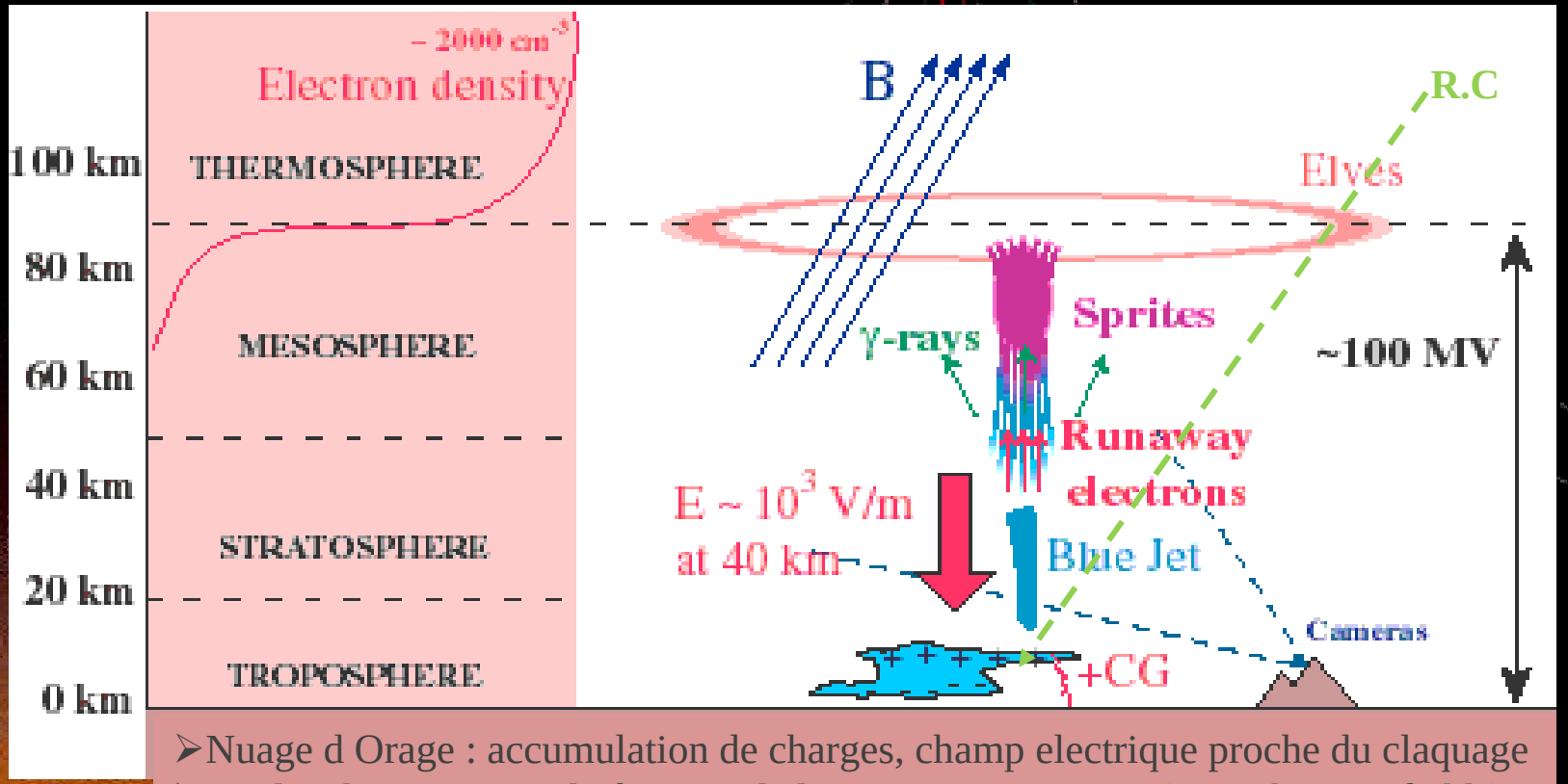




Orages de la Haute Atmosphere



Runaway Breakdown Model
EAS Assisted



- Nuage d Orage : accumulation de charges, champ electrique proche du claquage
- Avalanche initiee par la fraction d electrons energetiques (*Attachement faible*)
- **Assistance : Apport d electrons energetiques par une gerbe cosmique**

R.Roussel-Dupre, A.Gurevich, J.Geophys.Res,101,2297,1996

Geophysical Research Abstracts, Vol. 9, 00306, 2007
SRef-ID:

Towards a global research community in electromagnetic coupling of the atmosphere with near-Earth space

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Transient luminous events, denoted sprites, elves, blue jets and gigantic jets, are observed in association with particularly intense lightning discharges above thunderclouds. In addition to their optical signatures, transient luminous events can also be characterized by their distinct radio wave signatures. They also produce infrasound in the atmosphere and they have been associated with X- and gamma ray emissions in the Earth's atmosphere. Their occurrence rate may depend both on extraterrestrial phenomena (e.g. cosmic rays, meteorites, solar activity) and on environmental conditions (e.g. volcanoes, geomagnetic field, geomagnetic latitude). Transient luminous effects also have an influence on global processes (e.g. the global electric circuit).

New space missions are now planned to understand these phenomena and their origin, and to tackle the role of relativistic processes in atmospheric electrodynamics, e.g. the micro-satellite TARANIS, the ASIM payload on board the International Space Station and the sprite watch satellite. All these ground breaking space missions will result in challenging new data, which require knowledge based capacity building to underpin the new experimental observations with improved statistical data analysis and theoretical modelling. We propose to establish a global framework for research on (1) the triggering of lightning discharges and transient luminous events, (2) the physical coupling mechanisms between cosmic rays, lightning discharges, transient luminous events and terrestrial gamma ray flashes, and (3) the environmental impact of the above physical processes on the atmosphere, near-Earth space and mankind.

Atmosphere electrique

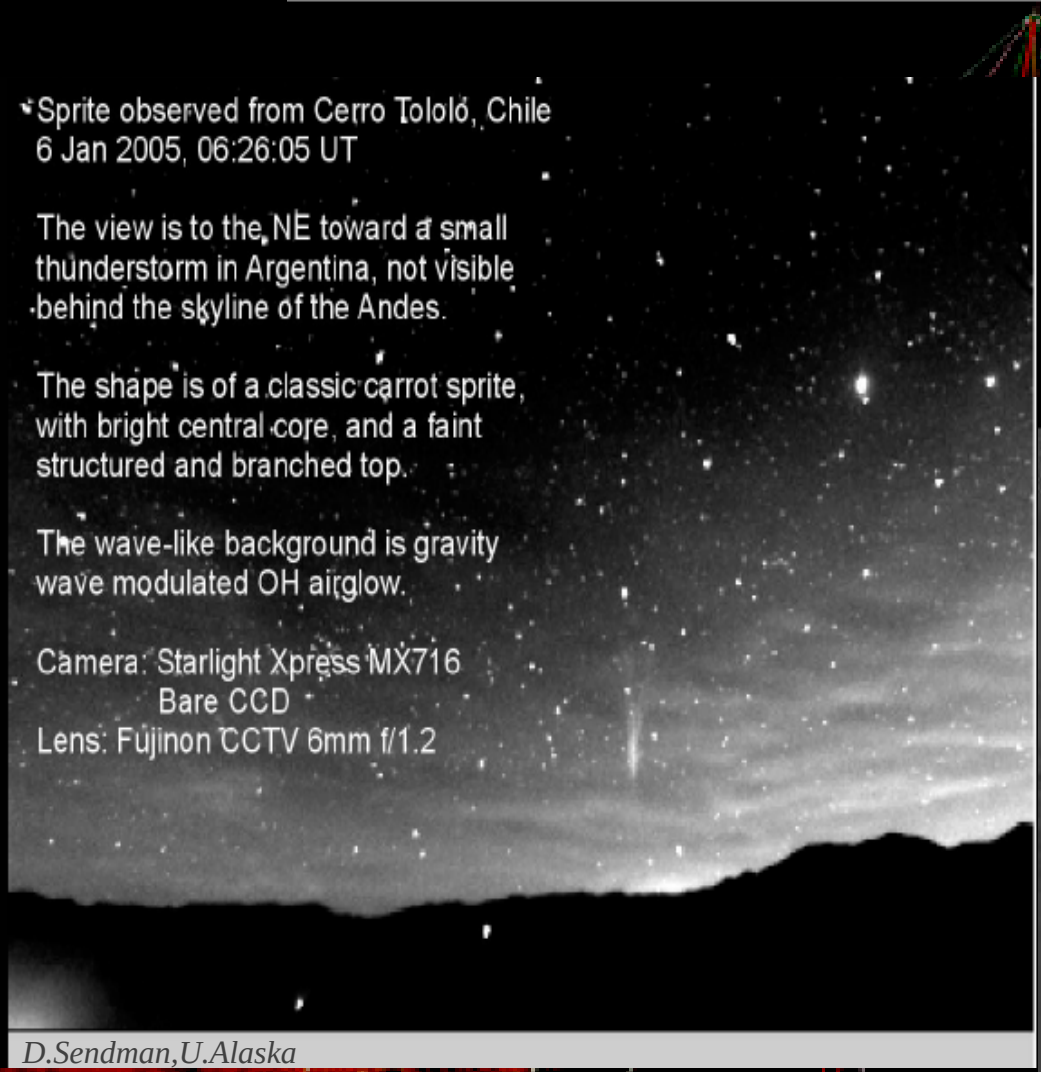
Convergence
Geophysique-Astroparticules
Sur l' etude des phenomenes
Transitoires de l'Atmosphere

En particulier Interet de la communaute des geophysiciens pour un couplage avec la Detection Radio

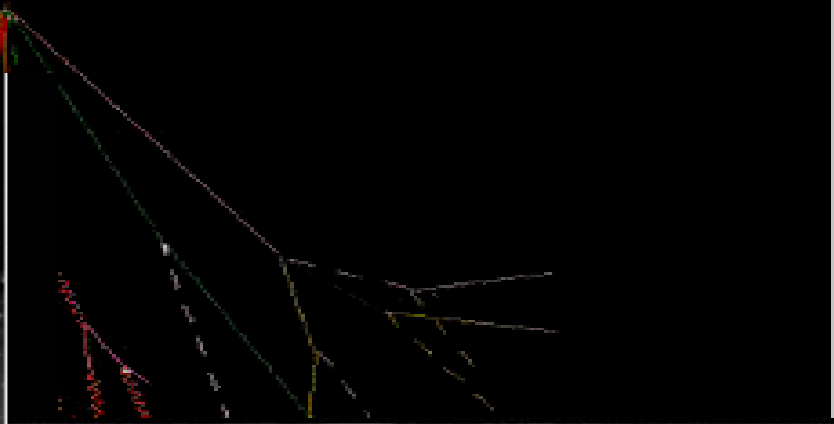
- projet LOFAR
- *programme Atmosphere*

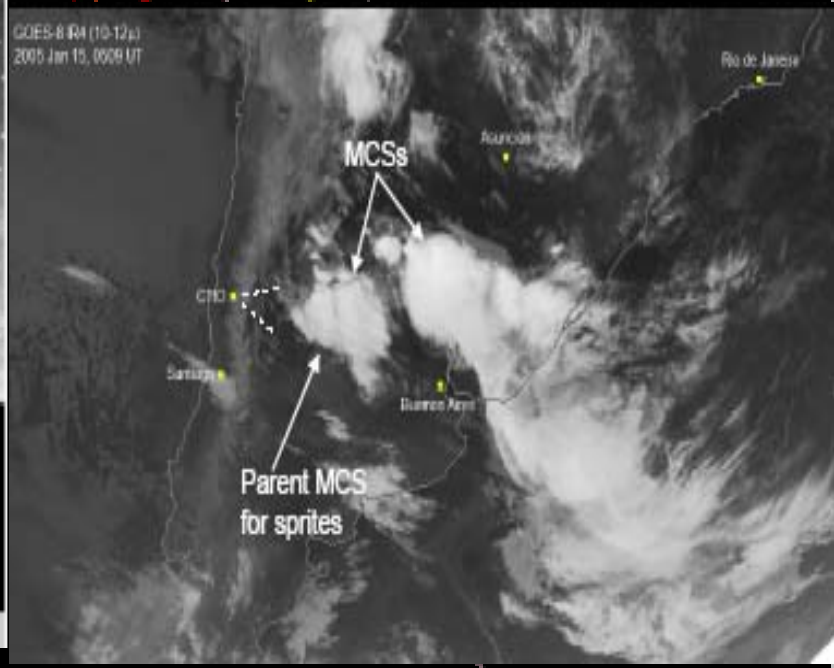
In CODALEMA / LPCE-Orleans

Sprites et RC ?

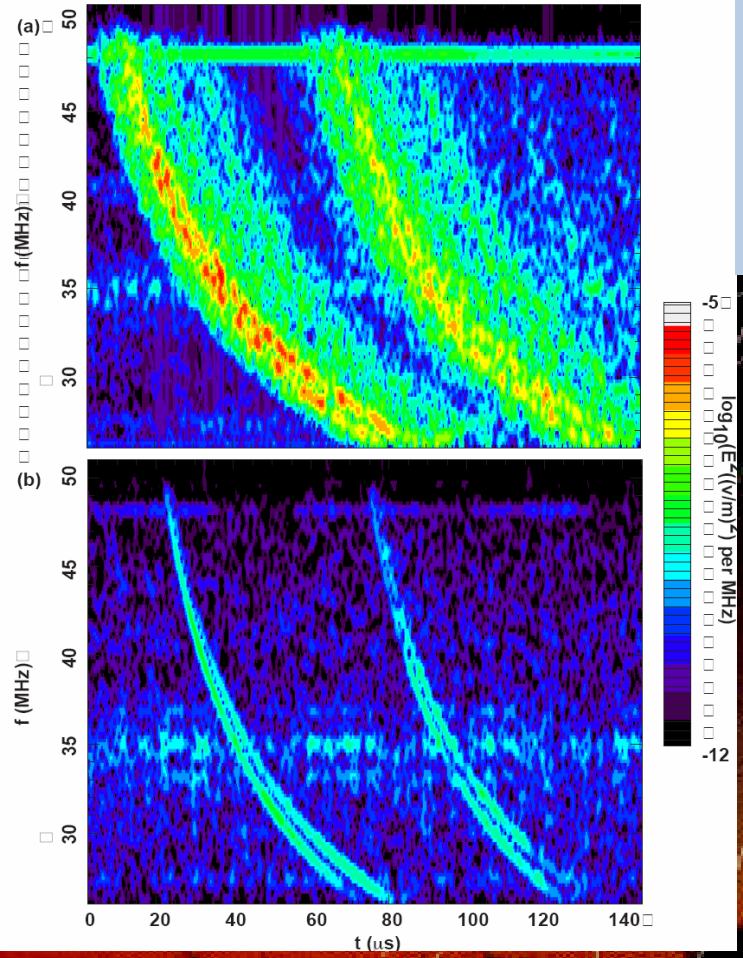


D.Sendman,U.Alaska





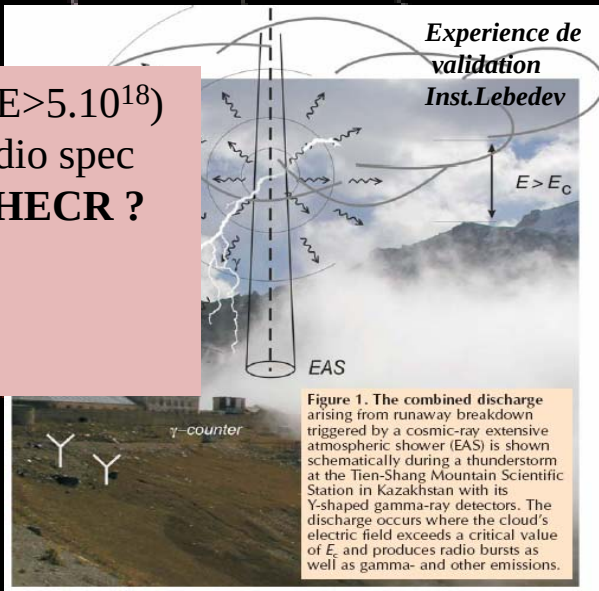
TIPPS, RadioBurst, Orages & EAS



❑**Observation satellite d intenses Radio Burts HF/VHF**
ALEXIS, FORTE
➢Associes a Orages Intra-Nuageux peu lumineux
➢TIPPS= Reflexion au sol ; donne l'altitude (5-15 km)
➢Narrow Bipolar Pulses ;Puissance enorme >40db

❑***Modele Runaway-Breakdown-EAS*** *(Gurevich)*
✓**Relation Puissance RB et Energie R.Cosmique**
➢Intensite Burst : J ~ $(E/10^{17})$ kA

➢Taux RB / EAS compatible ($E>5.10^{18}$)
➢portee ~1000km, signature radio spec
❑**Detection RB = detection UHECR ?**
• RB amplificateur
• Nouveau type de detection
• Surface S > 10^6.km^2



Different de la recherche directe de UHE ν dans les donnees de FORTE
Lehtinen, Gorham et al . PRD 69 (2004) 1318

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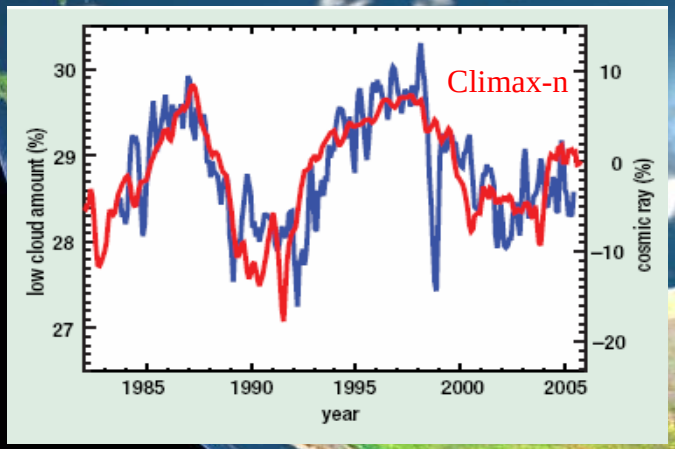
"Cosmo-Climatologie"

Astronomy & Geophysics, Volume 48, Issue 1, Page 1.18-1.24, Feb 2007

From The Times
February 12, 2007

'Blame cosmic rays not CO_2 for warming up the planet'

- **Lien Cosmiques - Couverture Nuageuse**
  Svensmark et al. 1997
- **Formation des Nuages par les cosmiques**
  Germes de condensation par aerosols charges
  Experiences en cours (ex : SKY , CLOUD @CERN)
- **Les Nuages Bas** ***(forçage negatif)***
  Les aerosols sont a basse altitude



Archeo-cosmo-climatologie

depuis ~1 siecle :

- Augmentation de l activite Solaire Moyenne
- Augmentation de la coupure Magnetique *(Long Forbush)*
- Moins de Rayons Cosmiques Galactiques
- Moins d' Ionisation de l atmosphere
- Moins de Nuages bas
- Moins de refroidissement

Correlation signifiative ?
Variation 1% ISCCP (erreurs ?, nuages hauts)
Source commune ? Autres variables (*TSI*)
Budget Radiatif , Forcage, ΔT(jour/nuit)….
Lien Rayonnement – Nuages Contre-exemples

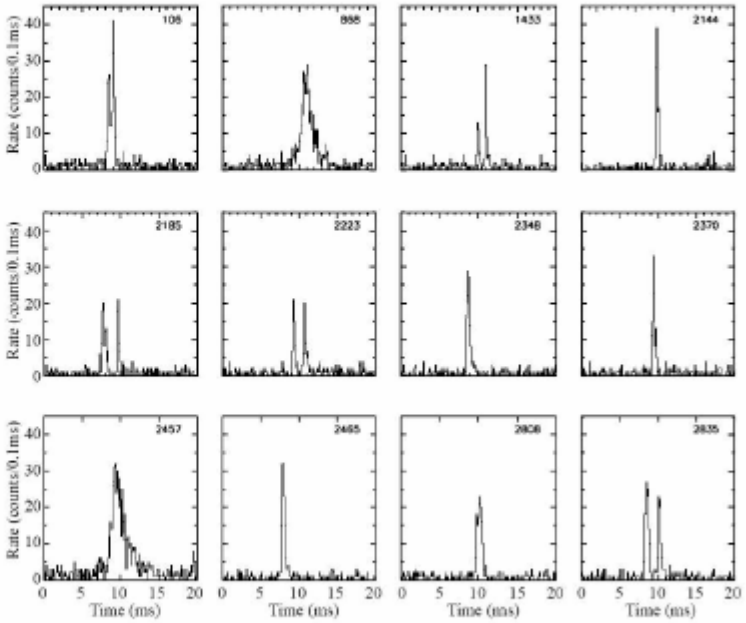
IPCC Fourth Assessment Report (AR4) , Working Group I Report "The Physical Science Basis"

	Evidence	Consensus	LOSU	Certainties	Uncertainties
Cosmic rays	C	3	Very Low	Some empirical evidence and some observations as well as microphysical models suggest link to clouds	General lack/doubt regarding physical mechanism; dependence on correlation studies

TGRB

Compton Gamma Ray Observatory BATSE Observations of > 1MeV Gamma Ray Bursts Originating From Thunderstorms

On account of the short mean free path of gamma rays in air, satellite observation of these pulses indicate a generation region that would lie at stratospheric altitudes or higher. To date, there have been only a few dozen such events reported.



Fishman et al. (1994)