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PREMOS/PICARD
LYRA/PROBA2

Instruments and Scientific Objectives

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Overview

• PREMOS/PICARD
  – Total Solar Irradiance
• Absolute calibration of TSI instruments
• Filter radiometers:
  1. PREMOS/PICARD
  2. LYRA/PROBA2
• Science goal → Nowcasting:
  – Solar influence on the terrestrial middle atmosphere
Launch schedules

- PICARD
  launch mid 2009

- PROBA2
  launch end 2008
  (probably beginning of 2009)
6.6.2008

PICARD

PREMOS

Total Solar Irradiance

Filter Radiometers
PREMOS/PICARD characteristics

- **MASS:** 11 kg
- **Overall Dimensions:** 270 x 327 x 160 mm
- **Power Requirement:**
  13W nominal
- **Data Rate:**
  3.6 MB/day
• PREMOS-TSI:
  – 2 absolute radiometers
    → internal evaluation of sensitivity changes

• PICARD TSI:
  2 TSI experiments as on VIRGO/SOHO

• Anticipated accuracy:
  – absolute accuracy to SI: ±0.1% = ±1 W/m²
    calibration against cryogenic radiometer at NPL
  – relative accuracy ±30 ppm
  – long term stability ±5 ppm/year

• PREMOS filter radiometers: ... see below
PREMOS & SOVAP on PICARD: new calibrated TSI experiments

Difference of the absolute level of TIM/SORCE versus all other experiments
Empirical TSI accuracy

Difference between active absolute radiometers 2003 – 2006

\[ <\text{VIRGO-TIM}> = 4.54 \pm 0.03 \text{ W/m}^2 \]

→ corresponds to \( \pm 30 \text{ ppm} \)!

trend 20 ppm in 4 years \( \square < 5 \text{ ppm/year} \)!!
TSI absolute accuracy

- All TSI experiments are absolutely characterized …
- VIRGO and SOVIM are traceable …!
- … to the World Radiometric Reference, the primary irradiance standard
  but …
Irradiance traceability

- Irradiance primary standard is the World Radiometric Reference (WRR) maintained at the World Radiation Center Davos
  
  … which is operated in air!

  → air-to-vacuum correction is needed, which introduces a large uncertainty term
Vacuum calibration at NPL

- PREMOS TSI instruments are calibrated in power against cryogenic NPL primary standard.

*New:* PREMOS will be the first vacuum calibrated space radiometer

Fehlmann et al. in preparation
Power comparisons

- Cryogenic primary standards for power exist; but ...

- ... in this case power-to-irradiance characterization is required

- power-to-irradiance accuracy of PREMOS has not been finalized (work in progress)

→ PREMOS irradiance accuracy is not yet known
Future TSI experiments

- GLORY (no launch date ?)
- SOVIM/ISS (launch February 2008) first observations still being evaluated
- PREMOS+SOVAP /PICARD (launch 2009)
- RAD/KuaFu-A the only future TSI experiment presently being considered by ESA (launch 2015 ??)
SOVIM, a PMOD/WRC experiment on SOLAR, a platform on COLUMBUS on the ISS.

Launch with space shuttle Atlantis February 7, 2008.
SOLAR on Columbus
SOVIM/SOLAR
Total Solar Irradiance observations between 2006 and 2012

ACRIM III  2000 - ?
VIRGO/SOHO  1996 - 2007 - 2009 + ?
TIM/SORCE  2003 – 2008 - 2012  (GLORY)
SOVIM/ISS  2008 - 2009 - ?
SOVAP/PICARD

KuaFu-A  2015(?)
TSI-instrumentation comprising:
SIM = Solar Irradiance Monitor (CN)
DOR = Davos Observatory Radiometer (CH)
Conclusions TSI

- Long-term relative TSI reconstruction is probably reliable to ±0.1 W/m² (0.01% , 100 ppm)
- With PICARD and SORCE the TSI observations are most likely continues and overlapping until about 2012 +
- So far nothing approved beyond 2012
- more than 1 TSI experiment in space at any time is mandatory!
2 solar instruments

- **LYRA**
  - UV radiometer
  - PI: JF Hochedez
  - PMOD/WRC built hardware
  - LYRA.oma.be

- **SWAP**
  - EUV imager at 17.5 nm
  - PIs: D Berghmans & JM Defise
  - SWAP.oma.be
LYRA (FM March 2006)

BESSY synchrotron calibration at PTB
LYRA integration on PROBA2
5.3.2007
LYRA/PROBA2 filter radiometers

Filter radiometers:

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cadence:
   – 50 Hz

channels (2 of each)):
   – 30 nm  (Zr-filter)
   – 70 nm  (Al-filter)
   – 121 nm  Ly a
   – 210 nm  O₃ Herzberg band
LYRA filters

Detector Response – Filter Transmittance

MSM Detector
PiN Detector

detector responsivity [A/W]

10^{-10} 10^{-8} 10^{-6} 10^{-4} 10^{-2} 10^0 10^2

filter transmittance

10^{-6} 10^{-4} 10^{-2} 10^0 10^2

wavelength [nm]

1 10 100 1000

Slide: J.F. Hochedez (ROB)
Filter radiometers:

cadence:
- 10 Hz in one channel (selectable)
- all others: 1 min

channels (2 of each)):
- 210 nm  (25 nm)  Herzberg O$_3$ band
- 215 nm  (7 nm)   Herzberg O$_3$ band
- 266 nm  (20 nm)  Hartley O$_3$ band
- 535.75 nm (0.6 nm) identical filters as on SODISM/PICARD
- 607.16 nm (0.9 nm) "
- 782.30 nm (1.7 nm) "

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Filter Radiometers

LYRA/PROBA2 (launch November 2008 ?)
PREMOS-PFR/PICARD (launch 2009)

LYRA: 30 (Zr), 70 (Al), 125, 210 nm

PREMOS: 215, 266, 535, 607, 782 nm
Filter wavelength selection

Ozone mixing ratio changes (%) due to a 10% increase of the spectral solar flux in 1 wavelength bin (1 nm).

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Rozanov et al. 2002: SOHO-11 ESA SP-508
science aims

- PREMOS - Total Solar Irradiance
  - Long term TSI monitoring

- PREMOS - Filter Radiometer
  - Support observations of SODISM/PICARD:
    - absolute and relative long-term calibration

- PREMOS and LYRA - Filter Radiometer
  - fast cadence observations: 10 Hz and 50 Hz
    - unknown domain!
  - Space climate: influence of UV irradiance on the climate
Space Weather Service

Hourly/Daily Data from observations by PREMOS, LYRA, SORCE

Radiation spectrum reconstruction 120-680 nm (Egorova et al., 2008, ACP)

Nowcast of neutral and ion composition in the mesosphere based on solar irradiance measurements

Nowcast of anomalies of neutral and charged species with free running CICM SOCOL

Output validation to improve the model and experimental set-up

Nowcast results available on web every 6 hours
Aim of Nowcast

- Find out how well we understand the solar influence on the middle atmosphere;
- Learn how to provide near-real-time operation;
- Space Weather Service is secondary goal but may become interesting if successful!
Reconstructing the UV (1)

Correlation of LYRA channels with other wavelengths

Radiation spectrum reconstruction 120-680 nm (Egorova et al., 2008, ACP)
Reconstructing the UV (2)

Correlation of proxies with UV Wavelengths

Radiation spectrum reconstruction 120-680 nm (Egorova et al., 2008, ACP)

SUSIM daily values (year 2000)

TSI
F10.7
NMD

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Ion chemistry in the D-region

Height-scale: 0-90 km; \( \Delta Z = \sim 2 \) km; time-steps: \( \Delta t = 2 \) h

Chemistry:

Electron density: \( e^- \)

30 positive ions:

- \( O^+ \), \( O_2^+ \), \( O_4^+ \), \( N^+ \), \( NO^+ \), \( N_2^+ \), \( H_2O_2^+ \), \( H_3O^+ \), \( O_2^+ \cdot N_2 \), \( O_2^+ \cdot H_2O \), \( H_3O^+ \cdot OH \), \( NO^+ \cdot H_2O \), \( NO^+ \cdot (H_2O)_2 \), \( NO^+ \cdot (H_2O)_3 \), \( NO^+ \cdot CO_2 \), \( NO^+ \cdot N_2 \), \( NO^+ \cdot H_2O \cdot CO_2 \), \( NO^+ \cdot H_2O \cdot N_2 \), \( NO^+ \cdot (H_2O)_2 \cdot CO_2 \), \( NO^+ \cdot (H_2O)_2 \cdot N_2 \), \( H^+ \cdot (H_2O)_2 \), \( H^+ \cdot (H_2O)_3 \), \( H^+ \cdot (H_2O)_4 \), \( H^+ \cdot (H_2O)_5 \)

17 negative ions:

- \( O^- \), \( O_2^- \), \( O_3^- \), \( O_4^- \), \( OH^- \), \( CO_3^- \), \( CO_4^- \), \( NO_2^- \), \( NO_3^- \), \( HCO_3^- \), \( ClO^- \), \( Cl^- \), \( CH_3^- \), \( O_2^- \cdot H_2O \), \( NO_3^- \cdot H_2O \), \( CO_3^- \cdot H_2O \)

43 neutral species:

- \( O_3 \), \( O^+ \), \( O \), \( O_2^+ \), \( NO \), \( HO_2 \), \( ClO \), \( NO_2 \), \( OH \), \( NO_3 \), \( N_2O_5 \), \( HNO_3 \), \( HONO_3 \), \( ClONO_2 \), \( Cl \), \( N \), \( N^+ \), \( H_2O_2 \), \( H \), \( HOCl \), \( Cl_2 \), \( Cl_2O_2 \), \( HCl \), \( Br \), \( CH_2O \), \( BrO \), \( HBr \), \( HOBr \), \( BrNO_3 \), \( BrCl \), \( CH_3 \), \( CH_3O_2 \), \( CH_3O \), \( HCO \), \( CH_3O_2H \), \( H_2O \), \( CFC-11 \), \( CFC-12 \), \( N_2O \), \( CH_4 \), \( CO \), \( H_2 \), \( CBrF \)

\( \sim 200 \) reactions for ions and \( \sim 200 \) neutral gaseous reactions

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Ion chemistry in the D-region

Ionization sources:
- Ly-alpha (above 65 km)
- Galactic Cosmic Rays (GCR) (below 65 km) (Heaps, 1978)
- Energetic Particles Precipitation (EPP)
- Solar Proton Events (SPE), data base from Jackman (2006)

Radiation:
- spectral region 120-780 nm with 73 spectral intervals (Rozanov et al., 2002)
- radiation data source for model validation: daily SUSIM/UARS observations
Validation

Difference of selected neutral and ionized species between solar maximum and minimum at 50° N

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1. Ionospheric model has been developed and validated

2. Ion-ion recombination reactions have been added which improved the model performance

3. Solar Proton Events have been implemented

4. Several experiments have been performed and we have verified that the neutral and ion compositions of the middle atmosphere are sensitive to the solar activity

5. Plans:
   - Continue to compare with available observations and models
   - 3D validation
   - Paper in preparation
Conclusions

- PREMOS - Total Solar Irradiance
  - Continue long term TSI monitoring

- PREMOS - Filter Radiometer
  - Support of SODISM observations
    - absolute and relative long-term calibration
  - Combine with LYRA/ PROBA2 fast cadence observations
  - Space climate: influence of UV irradiance on the climate
We are looking forward to PICARD science …

Thank you for your attention!

6.6.2008