# THE DYNAMICS PERSPECTIVE

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## ABSTRACT

The DynaMICS [1] space perspective is devoted to the long trend (decades or centuries) global properties of the Sun. Its main scientific objectives are: (1) to build a complete 3D rotating and magnetic picture of the Sun from the central core up to the chromosphere thanks to new observational constraints, (2) to deduce the different sources of dynamo and their interplay, (3) to build models of the already observed great maxima and minima solar activities and give some predictions for the coming decades, (4) to produce outputs useful to quantify the solar variabilities which impact on the Earth climate, (5) to extend the dynamical properties for solar-like stars and build dynamical stellar evolution codes. Understanding the magnetic field of the radiative zone is a crucial objective as it plays a key role in the long-term Sun-Earth relationship. We outline here the instruments: GOLFNG, MOF, SODISM, PREMOS, SOVAP that we are developing to reach this goal. They will detect, from space, solar acoustic and gravity modes together with radius and irradiance variations from UV to visible. Part of them will also improve our knowledge on the transition region between photosphere and chromosphere. These instruments must observe the Sun during a decade from an orbit which ensures continuity, stability and measurements of tiny variations.

Key words: Solar interior, Magnetic cycles, Sun-Earth relationship, Space Climate.

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[1]Dynamics and Magnetism from the Internal core to the Chromosphere of the Sun

## 1. THE PRESENT CONTEXT

SoHO has been extremely successful in improving our knowledge of the solar interior by helioseismology. Some of the problems addressed in the eighties have found a solution: neutrino predictions (Turck-Chièze 2005) and the different seats for the 11 year dynamo (Bonanno, Eltner & Belvedere, 2006; Dikpati, Toma, Gilman 2006). Others have strongly progressed like the description of the microscopic physics: nuclear physics, screening effect, equation of state, opacities. We evolve in fact from a static vision of the Sun to a dynamical one which allows us to concentrate now on human timescales after a good understanding of the very large timescales dominated by nuclear processes.

SoHO has opened a new era on the internal dynamics and the origin of the solar magnetism summarized in the review of Christensen-Dalsgaard (2002) and Turck-Chièze et al. (2005). Nevertheless it is important to mention that the present solar model is not yet able to explain the noticed great maxima and minima of activities associated with large Earth temperature variations (Eddy, Gilman & Trotter 1976, Ribes et al. 1988). It is also essential to establish the role of the Sun in the relatively flat temperature profile of the sixties-seventies despite the general Earth warming noticed since about one century (fig. 1).

Damon and Jirikowic (1992) have tried to estimate qualitatively (figure 2) how the different potential solar cycles: the Schwabe cycle (11 years), the Gleissberg cycle (90 years) and the Suess cycle (200 years) may produce the
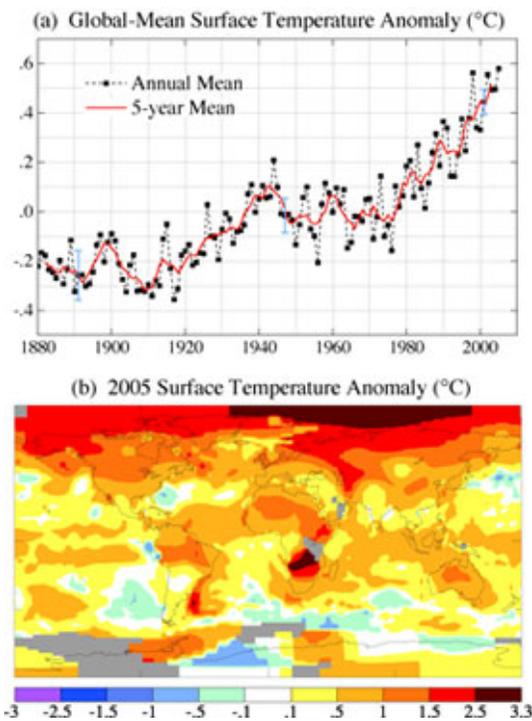
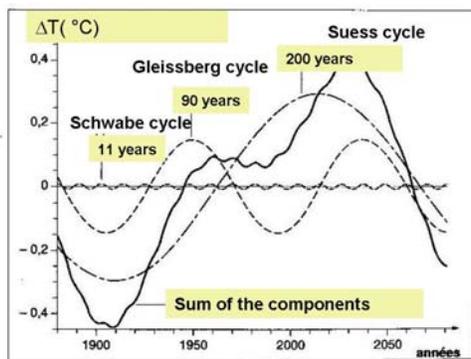Figure 1. *Time variation of the global mean Earth temperature and local Earth surface anomaly in 2005.*



Figure 2. *Prediction of Earth temperature evolution in supposing that the past warming was due to the different solar cycles effects. From Darmon and Jirikowic (1992).*
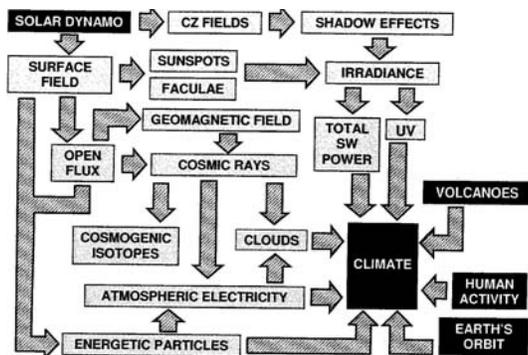


Figure 3. *The different contributors to the Earth climate. From Lockwood (2005).*

temperature variation observed on Earth. Assuming that the past temperature evolution is dominated by the solar activity, they get an interesting plateau at the same period of time as observed in figure 1, due to the interference between the various cycles. They get also a warming solar contribution up to 2040-2050 which may represent 30 % of the already observed phenomenon.

The fact that both human activities and the Sun may contribute to the Earth warming is not clearly established today. But if it is true that the two components lead to a present warming, it is not easy to disentangle the two different origins by pure external observations. On the other hand understanding what the Sun is doing is absolutely crucial to improve strongly the quality of the Earth climate modelling. It is very useful in order to better convince the different countries to limit the preponderant role of the human activities.

Nowadays we can develop the useful technology on both observational and numerical sides to understand and quantify the role of the Sun' interior to produce the variabilities at its surface which may contribute to part of the Earth warming. We hope also to establish wether the different previously mentioned cycles exist and if so, what have been and will be their relative amplitudes. With this perspective the DynaMICS project becomes a mission dedicated to fulfill part of the very rich and complex diagram described by Lockwood (2005) and recalled in figure 3. Six blocks will be covered: the determination of the different sources of dynamo, a better establishment of the surface field and open field and the determination of the total and UV irradiances. In considering different steps in this perspective we garantee to follow time evolution of the different variables along several decades.

Consequently, we propose a world-class project to study the long trend of the global solar properties in complement to the missions STEREO (2006-2009), SDO (2008-2013) and the european project Solar Orbiter which are mainly dedicated to high resolution measurements and space weather implications. The DynaMICS perspective includes successful European techniques used aboard SoHO or in PICARD (2008-2011). The dedicated instruments: the spectrophotometer GOLFNG (France/Spain), the radiometers PREMOS (Switzerland) and SOVAP (Belgium), the intensity measurement at the limb SODISM (France) and a magneto optical filter MOF first developed in Italy (Agnelli, Cacciani & Fofi 1975) have been recently improved for a new space mission. DynaMICS needs continuity and stability to measure all the global quantities: acoustic and gravity modes, radius, shape deformations, irradiance at different wavelengths. Some of them produce very low signals and most variabilities are known to be lower than $10^{-3}$. The best conditions for such a mission are:
- an orbit around the Lagrangian point L1
- about 10 years of observation after 2011
DynaMICS will also provide an insight into the photosphere up to the chromosphere dynamics by measuring Doppler velocity at different heights in the atmosphere and with different elements Na, K, Ca.

## 2. THE SCIENTIFIC OBJECTIVES

The DynaMICS perspective will contribute :

- to develop dynamical aspects of stellar evolution since the Sun is the unique star for studying the dynamical processes from the core to the chromosphere and even to the corona. The solar observations will stimulate 3D MHD simulations of stars,

- to provide a better insight on the transition region between the photosphere and the chromosphere,

- to understand the space climate by establishing the internal magnetic field in the different regions, the magnetic origin of each solar cyclic variability, the time evolution of irradiance at different wavelengths, their predictions for the next century.

### 2.1. The internal magnetic field

Magnetism plays a fundamental role in our Universe. The presence of magnetic fields is not only seen in the Galaxy and star formations. They are present in the elliptic galaxies and more and more attention is given to the magnetism of the stars and the relationship between the Sun and the Earth thanks to space missions as Ulysses, SoHO, TRACE, CLUSTER. But this fundamental ingredient is still poorly known and is absent from most of the equations currently used to describe our Universe. It is interesting to remark that although the 22 years solar cycle is now observed and established for centuries, it is not yet possible to predict without ambiguity the position of the next maximum nor the intensity of the coming cycle 24 (Dikpati et al. 2005; Schatten 2005). One may note also that the magnetic field is not present in the current description of the life of stars. Therefore, describing the magnetism of the solar interior represents an important objective for the next decade. From the observations of SoHO, we have tremendously improved our knowledge of the solar internal dynamics (Christensen-Dalsgaard 2002). Some crucial quantities are now observed as the sub-surface meridional flows, the zonal flows and the profile of the rotation down to the limit of the core. We can even follow them with time along the 22 years cycle and some smaller periodicity of 1.3 year near the tachocline region is suggested by the helioseismic observations in different instruments (Howe et al. 2000, Jiménez-Reyes et al. 2003). Dynamo models have been developed following Parker (1993) as an oscillatory dynamo in the Sun to drive the solar activity cycle. Important progress has been achieved these last years to predict more and more realistic dynamo models which are able to explain not only the mean period but series of cycles. But the prediction stays difficult and controversy is still present on the way to get the answer.

In fact direct measurement of the internal magnetic field has not been obtained and we have only estimates of limits on the mean field at different positions inside the Sun (Couvidat, Turck-Chièze & Kosovichev 2003a; Dziembowski & Goode, 2004). An upper limit for the magnetic field of 300 kG is given below the convective zone and 3MG for the core. This last value is deduced from the estimated deformation of the Sun (Friedland & Gruzinov 2004). Nevertheless, the activity of the outer layers along the solar cycle is followed by global acoustic modes. The corresponding magnetic field is estimated of the order of 10-50 kG and the variation along the solar cycle smaller than 100 G by Li et al. (2003). So, the pursuit of helioseismic observations with improved instruments is crucial to get quickly the complete dynamics down to the core and to catch the different actors. In parallel 3D MHD calculations of portions of Sun are developing. They have the objective to reproduce and explain the solar internal dynamics. A new challenge is to reproduce the flat radiative rotation profile (Thompson et al. 2003, Couvidat et al. 2003b) and the thin tachocline potentially sustained by the development of a magnetic field in the radiative zone to block the extension of the differential rotation downward (Gough & McIntyre 1998, Brun, Miesch & Toomre 2004; Brun & Zahn, 2006, Miesch, Brun & Toomre 2006).

The satellite SDO (Solar Dynamical Observatory), scheduled to be launched in 2008, will substantially improve the present dynamical picture of the convective zone. The improved resolution from MDI to HMI will give access to deeper, time-varying meridional circulation and will determine if different cells are simultaneously present. These observations must be pursued after SDO to observe the variation of the differential rotation which was supposed to be faster at the equator by 4% during the Maunder minimum (around 1600, Eddy, Gilman & Trotter 1976). A magnetic energy contribution of about 5-7% of the kinetic energy could lead to such slowing down (Brun 2004). These studies must be also extended to the radiative zone dynamics.

### 2.2. Irradiance at different wavelengths and radius variation

The Earth has experienced several climate changes showing periodicities extending from several hundreds of millions of years to short periods of 2300, 100 to 400 and 20-30 years having no obvious geophysical origin. Nevertheless the variation of the total solar irradiance seems too small to generate climatic changes such as the cold period of the 17th century. So one believes that non-linear feedbacks are needed to amplify the direct radiative effect. These feedbacks are not well identified, but likely involve the UV variation which affects the dynamics and thermal structure of the stratosphere, and the propagation of the planetary waves (Haigh 1996, Schlesinger and Andronova 2004, Egorova et al. 2004 see fig. 4). In the previous section we have shown how we can improve our picture of a dynamical Sun and try to find origins of different cycles. However, whatever the mechanisms are, a precise reconstruction of the total solar irradiance (TSI) is needed to validate climate models by comparison with climate records. This will allow to estimate the role of the solar irradiance variation, not only in the past but also for the present and the future, in order to separate the an-

thropogenic and the natural forcing. Moreover it is very important to follow the variation of irradiance in different wavelengths (Lean 1991) and also the variation of the radius to better interpret the observed phenomena, in parallel with the measurement of cosmic rays which may affect the high Earth atmosphere.
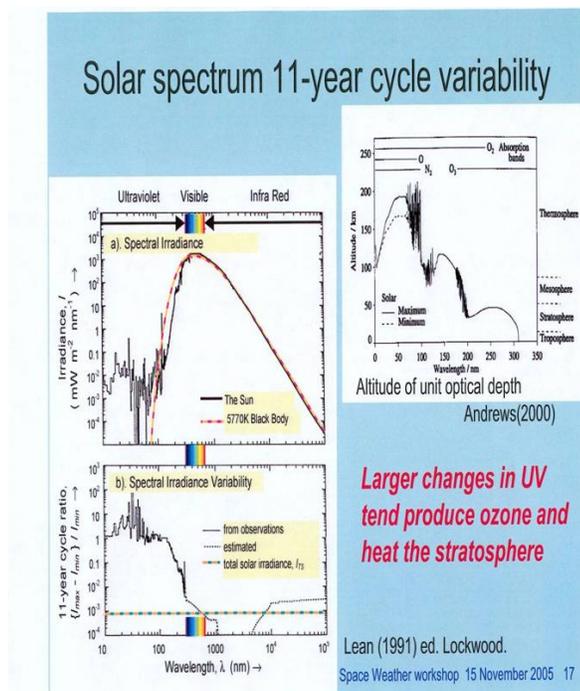


*Figure 4. Irradiance spectrum and time evolution along a solar cycle.*

SoHO has determined with an unprecedented accuracy the total solar irradiance variation of about 0.1 % along the 11 year solar cycle and a peak to peak variation following the rotation rate of 0.2% (Fröhlich & Lean, 2004). This variation is in phase with the solar cycle and dominated by the plages around the active regions or by the variation of the solar radius (smaller at maximum of activity) but to really understand the different processes which explain this phenomenon and its implication on the Earth, one needs to better describe what produces the cyclic variabilities at different wavelengths, in particular in ultraviolet and to follow independently the radius variation (see the following paragraph). One needs also to establish if there is a slow time evolution of the solar luminosity on a scale of centuries.

## 2.3. The transition region

It is noticeable that even though the acoustic modes are very sensitive to the surface layers, the surface transition region is too poorly known today. There are several reasons for that. It is a very complex region (see Lefebvre these proceedings) where turbulence and local magnetic field interact. Helioseismology has been developed without extracting the information above $0.97\ R_\odot$ and using an isothermal atmosphere. These simplifica-

tions were sufficient for the identification of the modes and the extraction of the sound speed and the rotation profiles. But most must be done for the quantification of the emergent magnetic field and the understanding and prediction of the evolution of the total luminosity. Recent progress must be considered using the information coming from f-modes which are the best way to extract information from the sub-surface region. Time study of
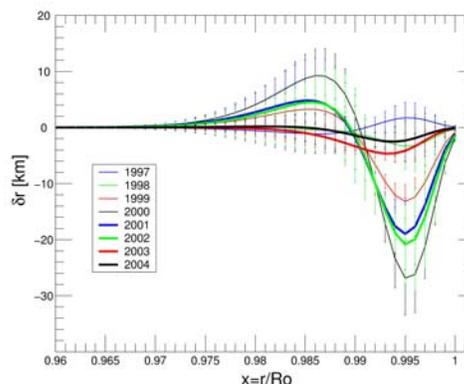


*Figure 5. Radial variation of the layers for each year along half a solar cycle, obtained by the study of f-modes. Note the behavior of the curves near $x = 0.99$. The error bars are the standard deviation after average over a set of random noise added to the relative frequencies. From Lefebvre & Kosovichev (2005).*

these modes along the solar cycle has revealed the presence of a double sheet: the region just below $0.99\ R_\odot$ seems to evolve in phase with the solar cycle although the region above seems in opposition of phase (Lefebvre & Kosovichev, 2005, fig. 5)). A latitudinal variation of these layers is under study and it will be extremely useful to associate to this study an independent measurement of the photospheric radius variation along the solar cycle to disentangle the different actors. The CNES microsatellite PICARD, scheduled also for 2008, will measure global quantities such as diameter and irradiance at different wavelengths and their variations during three years. Such efforts must be continued during the whole next decade.

## 2.4. The dynamics of the radiative zone

The radiative zone represents 98% of the total solar mass and cannot be ignored when one would like to study the long trend evolution of the Sun and the origin of magnetic activities at timescale of centuries. A complete dynamical picture of the Sun needs to include also the meridional motions of the radiative zone, the corresponding magnetic fields and the rotation profile down to the solar center. DynaMICS will put constraints on the energetic balance in the radiative zone and in the convective zone, including all the sources of energy (kinetic, meridional, magnetic, differential rotation ...) along time. This is the first milestone to improve the Earth climate modelling and leave the simplified picture where the photons are instantaneously transported to the surface. The first step is

the inclusion of the transport of angular momentum by rotation, gravity waves and magnetic field (see Mathis these proceedings and Mathis & Zahn 2004, 2005).

Such quantities will benefit from the detection of some gravity modes. Gravity waves are generated by strong plumes at the base of the convective zone, they can carry efficiently angular momentum during the first stages of evolution (Talon & Charbonnel 2005). Some of them create modes which are trapped inside the radiative zone. The theoretical predictions (Andersen 1996, Kumar et al., 1996) estimate that the gravity modes equally spaced in period have a visibility at least a factor 10 smaller than those appearing in the upper part of the gravity frequency range. Moreover, they have shown that their surface velocity may be fraction of a mm/s.
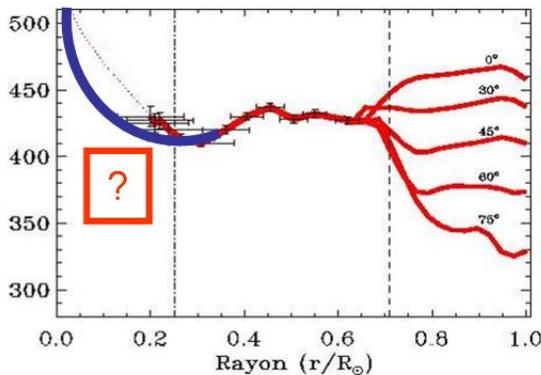


*Figure 6. Rotation profile obtained from acoustic modes detected by GOLF+MDI/SOHO. The blue part is an extrapolation of the rotation in the nuclear core suggested by the different analyses of gravity modes using the GOLF instrument.*

Gravity modes have been searched for more than 20 years. The limit of detection on ground was 4-7 cm/s (Delache and Scherrer, 1983; van der Raay 1990). The satellite IPHIR using luminosity variations has not really improved the detection limit: 1.3 ppm at 20 $\mu$Hz corresponds to some cm/s (Frölich et al. 1991). The GOLF/SoHO instrument, measuring the Doppler velocity has been specifically designed to detect velocities down to 1 mm/s thanks to a very low instrumental noise. Gravity mode multiplet candidates have been identified with the GOLF spectrometer in the upper frequency range (Turck-Chièze et al., 2004a,b). Such patterns are very sensitive to the core and to the whole static and dynamics radiative zone (Cox & Guzik 2004, Rashba, Semikoz & Valle 2006) and their identification is limited by the absence of masks at the entrance of the instrument. In the lower asymptotic regime of the spectrum one has detected a strong signal compatible with the asymptotic behaviour of the dipole modes (Garcia et al. 2006 these proceedings). These two analyses both suggest that the rotation is higher in the solar core than in the rest of the radiative zone as a relic of the young Sun (figure 6 and Turck-Chièze et al. 2006a for a review). Such information is extremely important to put constraints on magnetic fields

in the solar nuclear core. This perspective encourages to improve the capability of detection to open the golden era of gravity mode physics which will reveal the dynamics of the whole radiative zone.

We summarize here the main scientific questions to be answered by the DynaMICS perspective as breakthroughs :
- How do the gravity waves enter in competition with the magnetic field to maintain a flat radiative rotation profile between 0.4 to 0.7 R$_\odot$ ?
- Is there differential rotation in the solar core ?
- How do the dynamical phenomena evolve with time ?
- How do the magnetic field of the radiative zone and of the convective zone interact ?
- What is the strength of the toroidal magnetic field in the radiative zone?
- Can we understand sufficiently well the origin of the external magnetism to anticipate its effect along the next century and quantify how the Sun participates to the climatic evolution on Earth ?
- Can we quantify properly the irradiance at different wavelengths, radius and solar deformation variations over several decades ?
- Can we deduce and predict grand maxima and minima of activity from such information as one has already observed in medieval period or during the Maunder minimum ?

## 3. THE NEEDED OBSERVABLES AND THE IMPROVED TECHNIQUES

After more than 20 years of helioseismology on ground and in space, our capability of diagnostics has substantially improved. We concentrate here on the needed observables and the instrumental improvements affecting the global quantities.

### 3.1. The dynamics of the radiative zone: GOLFNG/SODISM

The sensitivity of the acoustic modes is maximal in the outer layers and very well adapted to study the convective zone. These modes are also appropriate to probe the static physics of the radiative zone if one can properly extract the information coming from the most external layers (Garcia et al. 2001) and put some constraints on the rotation profile down to the core limit. f-modes allow to improve our knowledge of the surface layers and the sensitivity of the gravity modes is maximal in the solar core.

The use and results of three instruments aboard SoHO have shown that the Doppler velocity technique is superior to the intensity one to detect a very large range of acoustic modes (Bertello et al. 2000, Garcia et al. 2001, Turck-Chièze et al. 2004b). In GOLF, the solar granulation is presently the main source of noise in the range around 1mHz for acoustic modes and in the range below 300 $\mu$Hz where the gravity modes are standing. So one needs to improve the signal to noise ratio below 1 mHz in both reducing the solar noise and in amplifying the gravity mode signal for detecting a maximum of modes in a

minimum of time (typically one or two years and not 10 years), Moreover the spectrum of gravity modes is dense so the identification of the components of the observed patterns necessitates local measurements or masks at the entrance of the instrument. Detection and identification of degrees up to 5 for gravity modes is an objective for the near future. It is clear that already several unambiguous detections of gravity modes between 100 to 400 $\mu$Hz will tremendously improve our knowledge of the solar core. Moreover the asymptotic region analyzed globally puts strong constraints on the core rotation profile and also on the magnetic field in the nuclear core which contains half mass of the Sun. It is why since 1998, we develop three new instruments which integrate the knowledge of the different techniques. Finally one has noticed that due to the tiny amplitude of the signals (for which we are also interested in the variation) it is extremely useful to have different instruments on board approching the same kind of modes in different ways. It is why we propose three seismic instruments for the DynaMICS perspective: SODISM, GOLFNG and MOF.

The new intensity instrument called SODISM (SOlar DIameter and Surface Mapper, Thuillier et al. 2006) has been developed to determine the oblatness of the Sun and will follow the change in radius during the three years which are the main objectives of the PICARD mission (see below). It must also improve the intensity detection using the fact that the gravity modes must be amplified at the solar limb (Wachter, Haberreiter, Kosovichev 2004), although one needs to reduce also in parallel the amplification of the solar noise. Considering the experience on SoHO and the remarks mentioned above, a simultaneous measurement by GOLFNG in space will better ensure a greater scientific return for the detection of gravity modes.

The GOLF-NG (Global Oscillation at Low Frequency New Generation) instrument developed in CEA/France in collaboration with IAC/Spain is described in Turck-Chièze et al. (2006). It is the same technique of resonant spectrometer than GOLF. It consisqts in measuring the Doppler velocity variations. Such technique has allowed the best determination of low signals for gravity and acoustic modes. The improvement consists of measuring the velocity at different heights from the photosphere to the chromosphere with non coherent patterns of solar noise and to introduce masks at the entrance of the instrument for identification of the observed components.

The principle of the GOLF-NG instrument is to measure the Doppler shift of the D1 sodium Fraunhfer solar line by a comparison with an absolute standard given by the sodium vapour cell, the heart of the experiment. A small portion of the absorption line provided by the resonance of the light in the vapour cell split into its Zeeman components by means of a static longitudinal magnetic field whose strength varies along the longitudinal axis in order to explore different heights of the atmosphere. By changing the circular polarization of the incoming flux, it is possible to select 8 points on the right wing of the line or 8 points on the left wing, with one in common at the

center of the line. Moreover the analyzed flux has been increased by a factor 10 to lower also the noise level coming from the instrument and to allow consecutive measurements of portions of the Sun. A second crystal polariser could allow the determination of the spectrum of the mean magnetic field. A prototype of such instrument is in construction in CEA/Saclay and will be set up in Tenerife at the end of 2006 or in 2007.

### 3.2. Time evolution of irradiance and radius: SODISM/PREMOS

The SODISM instrument has been developed at Service d'Aéronomie of CNRS/France for the mission PICARD. It is made of an imaging Cassegrain telescope and a CCD $2048 \times 2048$ which collects the solar images in five wavelengths with an accuracy better than 1 mas. Such instrument will carry out the measurement of the solar diameter, solar asphericity, and some helioseismic observations using the amplification of the modes at the limb and $16 \times 16$ macropixels of the whole Sun.

The PREcision MOnitoring Sensor (PREMOS) is provided by the Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center (PMOD/WRC, CH). PREMOS sunphotometers consist of 3 identical instruments, where each unit has 4 channels with central wavelengths at 215, 268, 535, and 782 nm. Today, the absolute calibration of the spectral irradiance is of the order of a few percent in the visible and up to 10% in the UV so one needs in the future to find a way to characterize very low increase or decrease of the irradiance along decade which justify improvements of the technique used in SoHO (Habbereiter et al. 2005). This is why a new generation of precision filter radiometer is presently being studied. In addition PREMOS comprises two absolute radiometers which will measure total solar irradiance continuing the series of high accuracy TSI observations of VIRGO/SOHO and TIM/SORCE.

SOVAP is a differential absolute radiometer developed by RMI (Belgium). It is the successor of DIARAD aboard SoHO (Dewitte et al. 2004). It is a recurrent design with gradual improvement with time which measure the total irradiance every 2 mn, it is accompagnied by a small bolometric oscillation sensor with a sampling of 10s. SOVAP will use the reference channel for monitoring the ageing effect, so it must have a repeatability of 100 ppm through one solar cycle. It will also allows comparison with PREMOS and with other measurement like TIM/SORCE. In addition to these different measurements of irradiance one needs to add some UV measurements.

### 3.3. From Photosphere to Chromosphere, the Magnetic flux: GOLFNG/MOF

Our main objectives are to follow all the global quantities, so it is important to get reliable information on the region located between the photosphere and the chromosphere, to see the emergence and the time evolution of the mean magnetic field. We propose in this project two

complementary studies to improve the description of the solar atmosphere (profiles of T, $\rho$, and B)
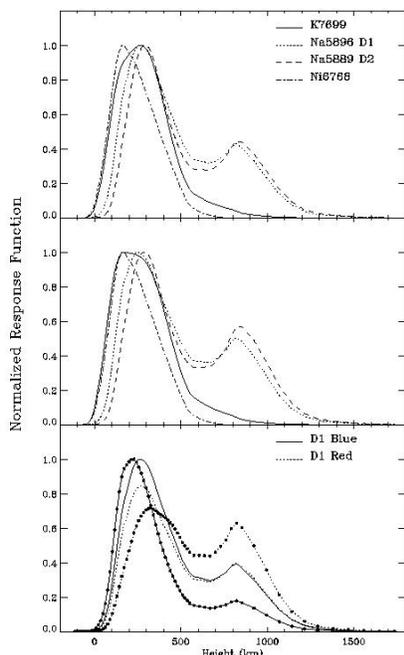


*Figure 7. Different absorption lines sensitivity to the atmospheric height between photosphere and chromosphere. From S. Jimenez-Reyes (2006)*

GOLFNG will explore 8 heights in the atmosphere with the sodium line from the photosphere up to 800 km and consequently will follow the time evolution of the line due to the variation of the magnetic field. It is a simple instrument well calibrated by the continuum for the different channels so it allows a direct comparison of the different heights to follow the impact of granulation, supergranulation, active regions and chromosphere (Espagnet et al. 1995, Eibe et al. 2001).

The MOF (Magneto-Optical Filter, Cacciani & Fofi, 1978), is used for imaged Doppler and magnetic field observations of the Sun. The strengths of the MOF lie in its wavelength stability, its narrow pass-band (approx. 0.005nm) and its high throughput. This instrument will use the Na at 589 nm, the potassium D-lines at 770 nm and the Ca I line at 422 nm which is formed in the mid-chromosphere. So it will probe the acoustic properties of the low atmosphere beyond the cut off frequency, it can thus provide a probe both for velocity and magnetic field information together. It will map the spatial and temporal changes in the vertical travelling time between the mid chromosphere down to the photosphere. The MOF technique has been under development for ground observations for three decades and is used by different groups at different places: observatories, network and South pole (Tomczyk et al. 1995, Cacciani et al. 2003, Magri et al. 2005, Vecchio 2006, Jefferies these proceedings). It is important also to mention that this technique allows also the detection of a large range of acoustic modes.

## 4. STRATEGY OF OBSERVATIONS

The DynaMICS perspective has defined complementary instruments which altogether answer to a very timely question with direct social impact :
*What are the internal variations of the Sun that influence the terrestrial climate ?*

DynaMICS will quantify the different global quantities which are at the origin of a climatic interaction between the Sun and the Earth. This project is the first step of the chain of processes which include the reacting magnetosphere, the formation of clouds, the aurorae ... Up to now it is important to notice that this first step is totally missing and that a constant irradiance is introduced in the climatic model calculations. So it is absolutely necessary to build complex models of climate which include a better description of the variabilities coming from the Sun: this supposes not only measurements of external phenomena but also a deep understanding of their origin. During the last 10 years, we have being able to develop new techniques which considerably enrich the picture of the dynamical Sun and give confidence that we are able to enrich the inputs of the climatic models.

Different strategies of observations are under discussion today justified by the importance of time continuity in global quantity measurements. Effectively, although sunspot indicators have been maintained for decades, useful helioseismic and irradiance measurements are only available for one or two decades and not for all the indicators nor for all the wavelengths. All the observables must be followed for several decades in order to establish the real climate Solar-Earth connection. It is why we are preparing reliable, low cost, low weight instruments which must be launched for long and uninterrupted observations. A Proteus platmform developed by ALCATEL/ALENIA is perfectly adapted for this mission.

We are also convinced that we need redundancies in methods to detect without ambiguity small signals and small time evolution. The DynaMICS project includes all these aspects and will be proposed in the framework of ESA Cosmic Vision, for a mission of about 100 kg of instruments orbiting around the Lagrangian point for a long duration, it must be a world-wide mission which will benefit from other agencies around the world. Aboard the platform it stays some possibility for complementary instrumentation in the perspective of two satellites including a Solar Polar one.

In the meantime, SDO, PICARD will improve some aspects of this problem and will carry parts of the mentioned instruments. We will substantially improve the scientific return of this coming decade if we put in orbit in parallel GOLF-NG. So, we are hoping synergies with other missions that are proposed for the time after 2011 like the NASA sentinels, the Chinese Kua Fu A mission, both missions observing at the L1 point, and we will not neglect any other opportunity.

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