THE EARTH AS AN EXOPLANET

PhD: Illeana Gómez Leal

Tutor : Franck Selsis

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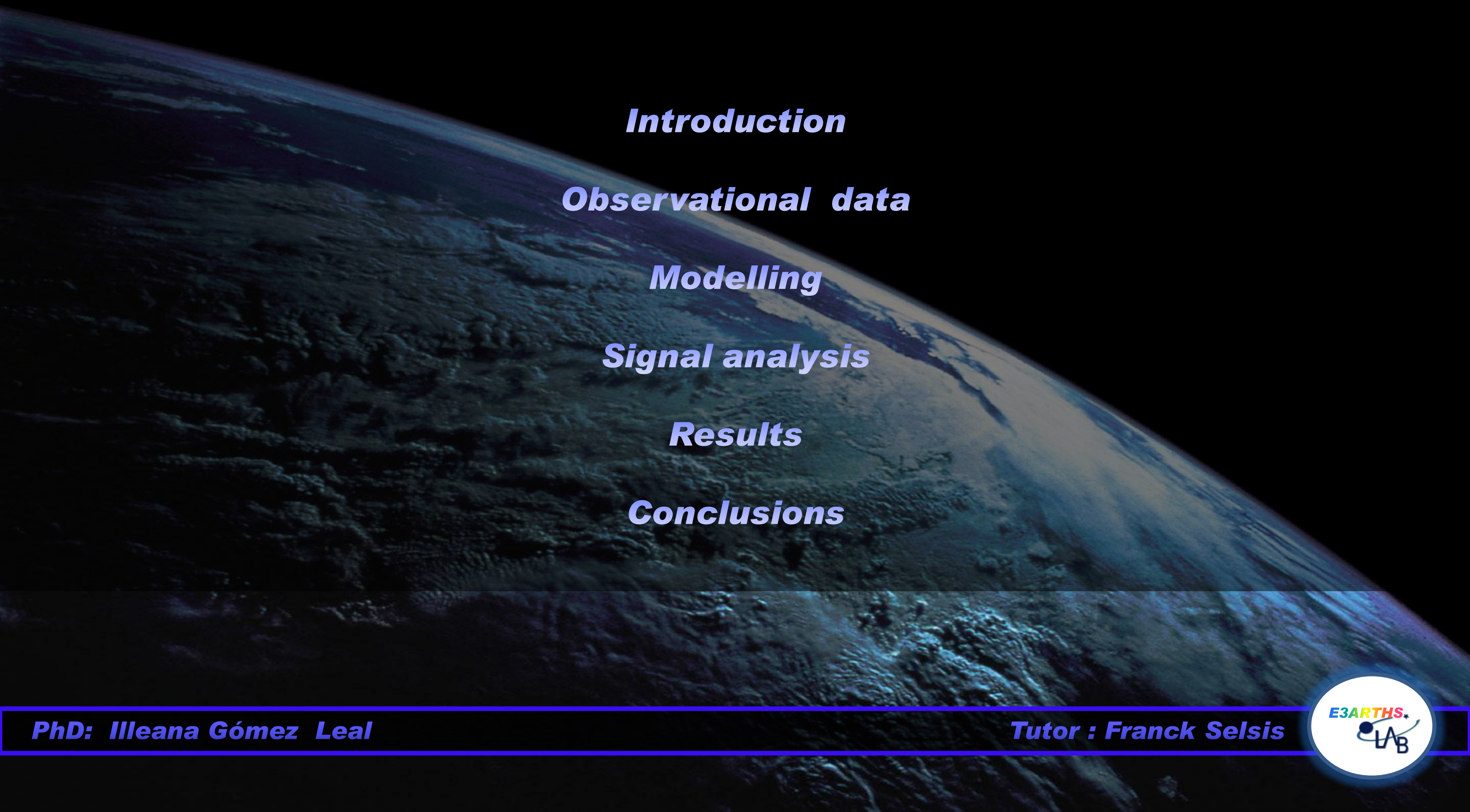

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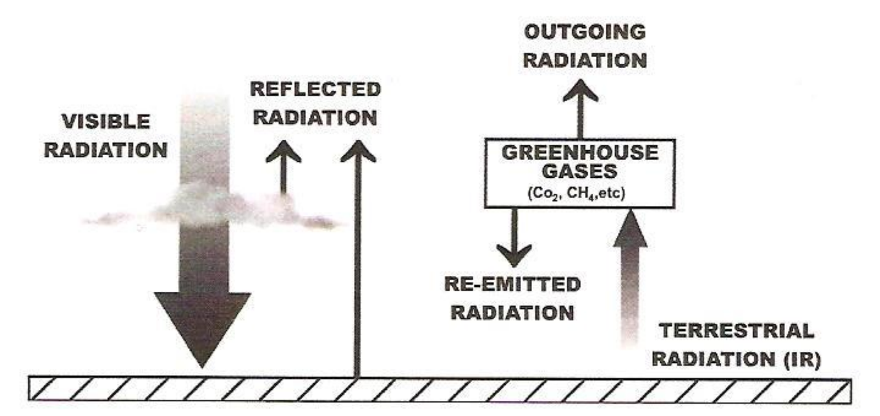
Infrared terrestrial emission

$$F_{abs} = F_{emit}$$



$$(\pi R_E^2) F_S (1-a) = 4\pi R_E^2 F_E$$

$$F_E = (1-g)\sigma T^4$$

$$T_{eq}^4 = \frac{F_S(1-a)}{4\sigma(1-g)} = \frac{L_S(1-a)}{4d^2\sigma(1-g)} \rightarrow \mathrm{T} \approx 288\ \mathrm{K} \rightarrow \lambda = \frac{2898\,\mu m}{288K} K \approx 10\,\mu m$$

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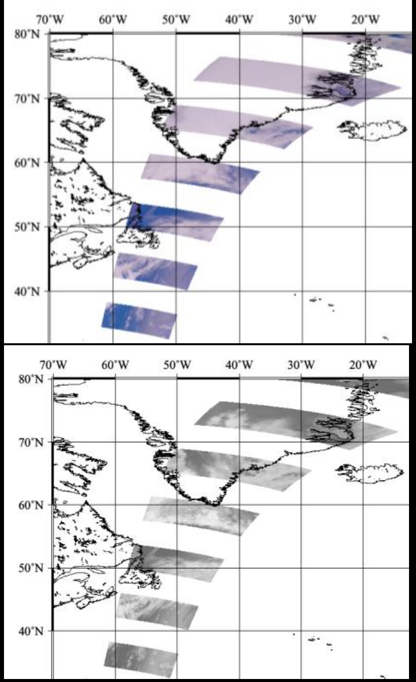


***GEWEX** Global Energy and Water-cycle Experiment (NASA)

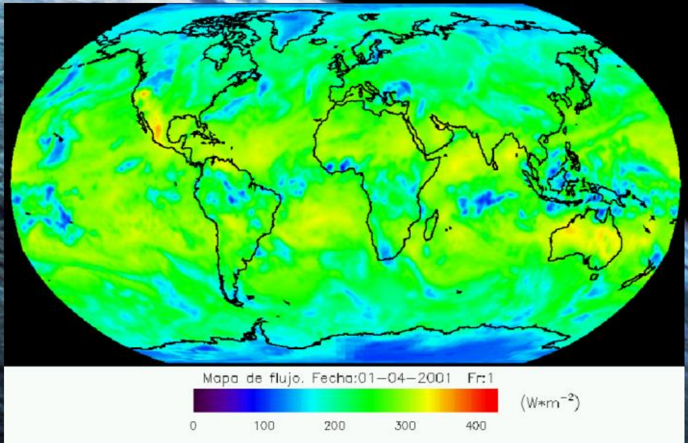
SRB Surface Radiation Budget

LW Longwave radiation ($\lambda > 4.0\ \mu m$) $\varepsilon = \pm 5\ W/\ m^2$

* Data period: 1986 - 2001

* Observations each 3 hours:
(0, 3, 6, 9, 12, 15, 18, ,21) hrs UT per day.

* Numerical matrices of 1ºx1º (lon,lat) resolution.
transformed in emission flux maps.



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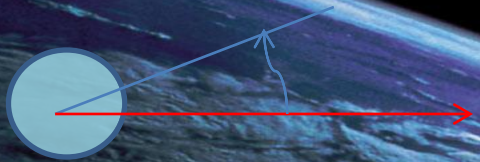
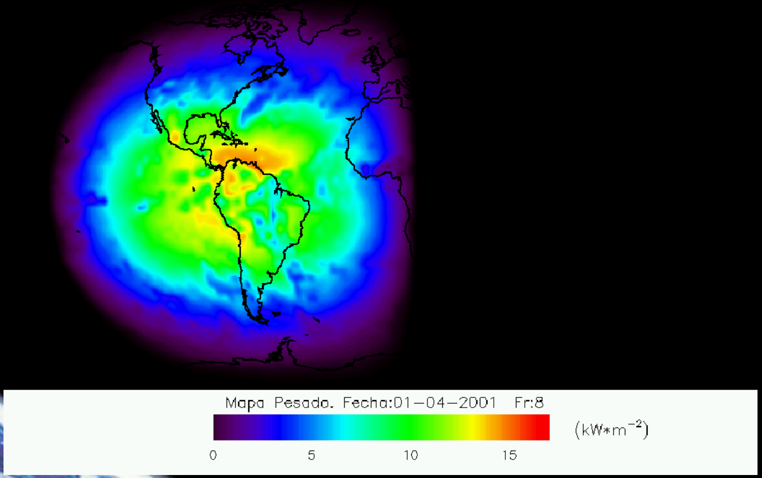
Geometrical model

Planetary disk simulation

Weight map= flux map*area map*cos map

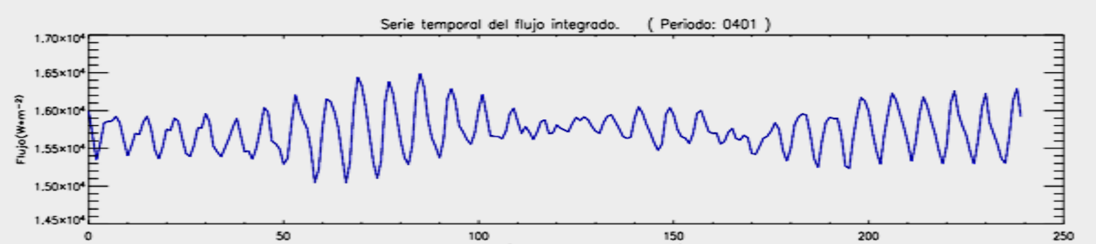




Point-like signal

Integrated flux= ∫ (Weight map) ds

It’s transformed in a flux vector
-> time series



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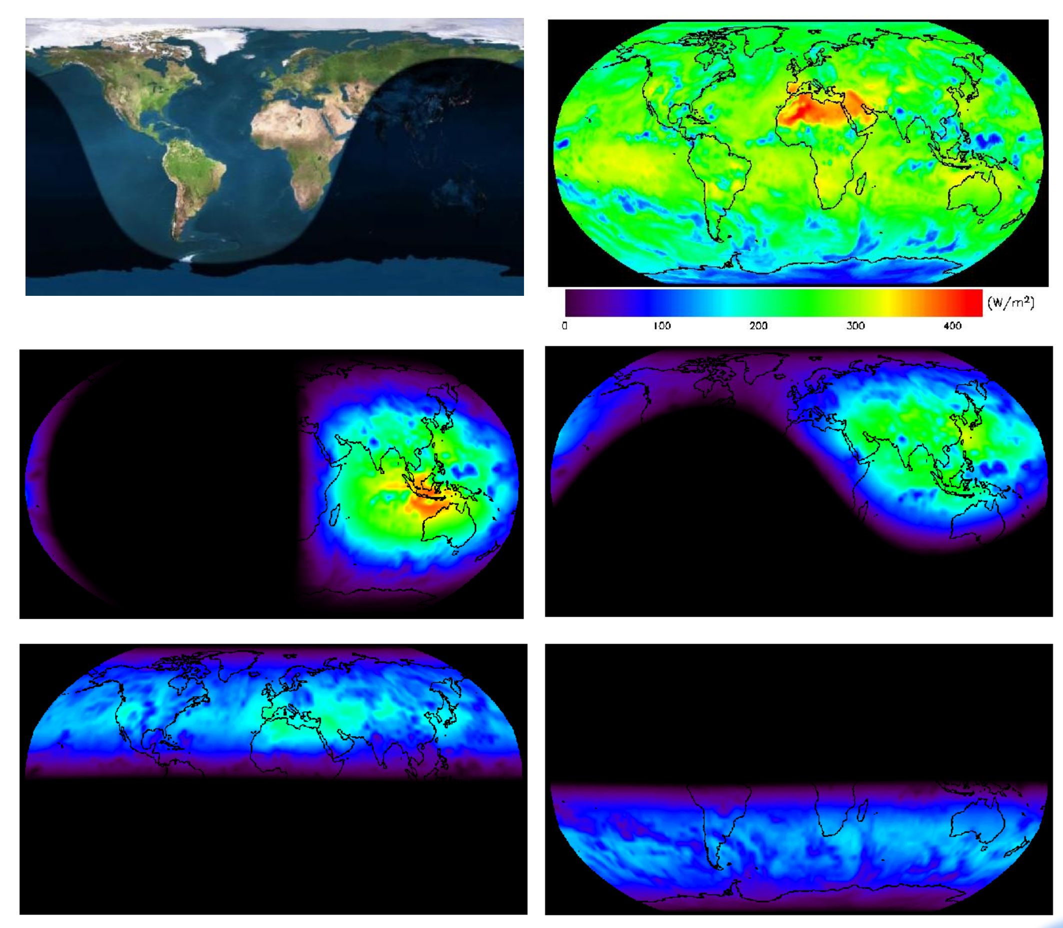
Variation of the observer's geometry

Inclination angles

Equator ,45º N , 90º N, 90º S.



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Time series

Annual maximum (~5%) in boreal summer.

“Northern-hemisphere” behaviour.

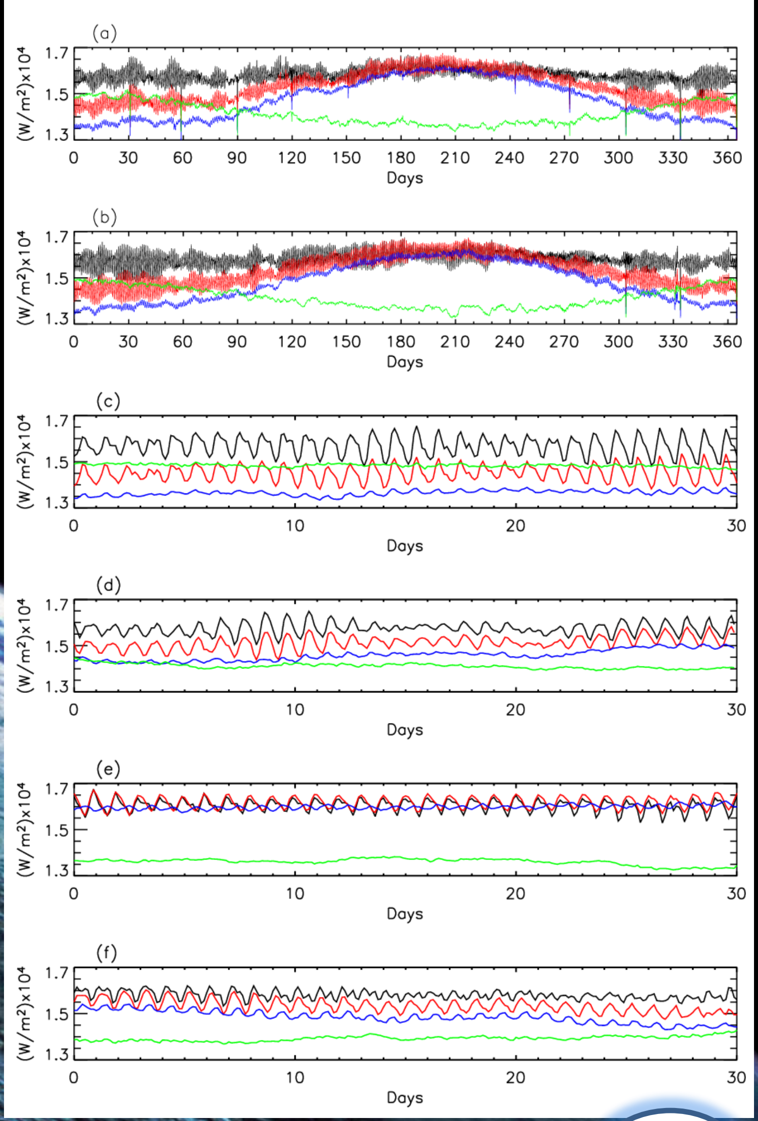

Fig. 5.— Time series. From top to bottom, the years of 1987, 2001 and January, April, July and October 2001 for 90°, 45°, 0° and -90° inclination angles (black, red, blue and green lines respectively).

Table 1: Photometric variability of the integrated infrared flux at several time scales and seasons.

Annual Time Series Variability (%)

Inclination angle	1987	2001
0°(Equator)	4	3
45°(Mid-latitude)	12	11
90°(N. Pole)	17	17
-90°(S. Pole)	10	10

Daily Mean(Max)Time Series Variability (%)

Inclination angle	Jan	Apr	Jul	Oct
0°(Equator)	7(11)	4(9)	4(8)	3(6)
45°(Mid-latitude)	7(8)	4(8)	4(8)	4(6)
90°(N. Pole)	1(2)	1(2)	1(2)	2(3)
−90°(S. Pole)	1(2)	0(1)	0(2)	0(1)

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Light Curves

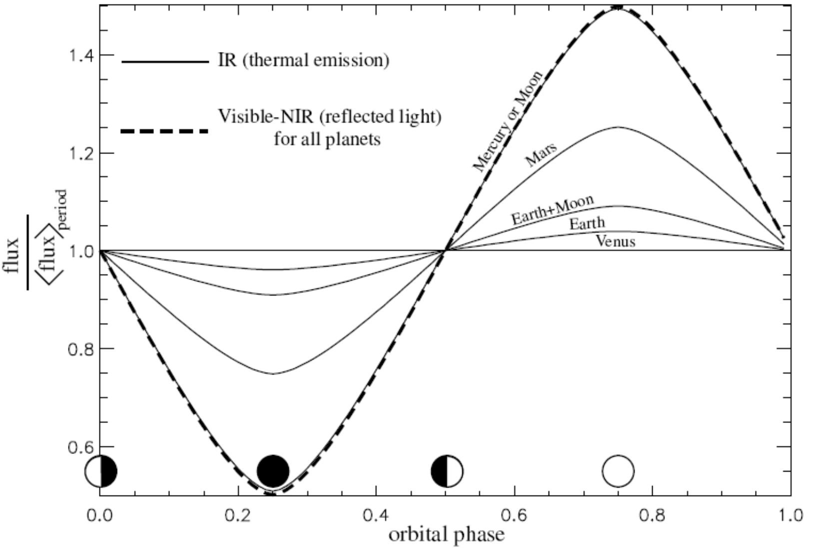
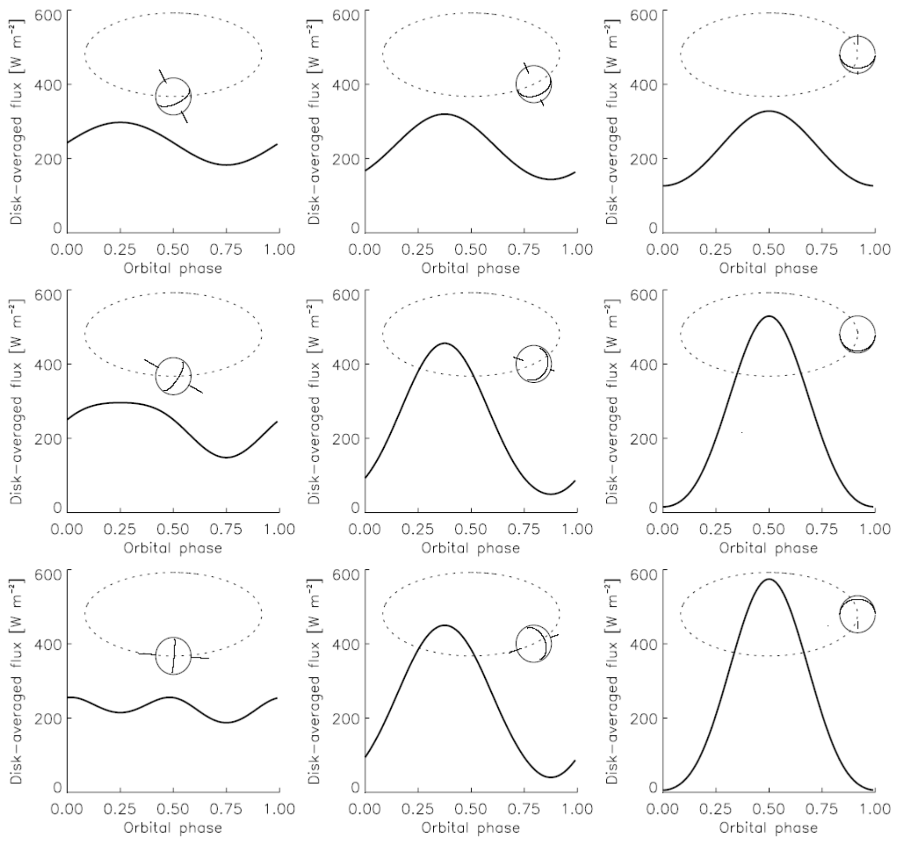


Figure 2. Variation of IR flux over an orbital period for different kinds of planets. The reflected light received from a planet is directly proportional to the illuminated fraction of the planet (visual phase: ϕ). In return, the IR emission only follows the variation of ϕ for atmosphereless planets. In this simple model the planets have null obliquities and circular orbits seen with an inclination of 45°.

Selsis, 2004



Gaidos, 2004

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Light Curves

* Maxima and minima change with season.

* Equator and mid-latitud viewing angles show variation with day.

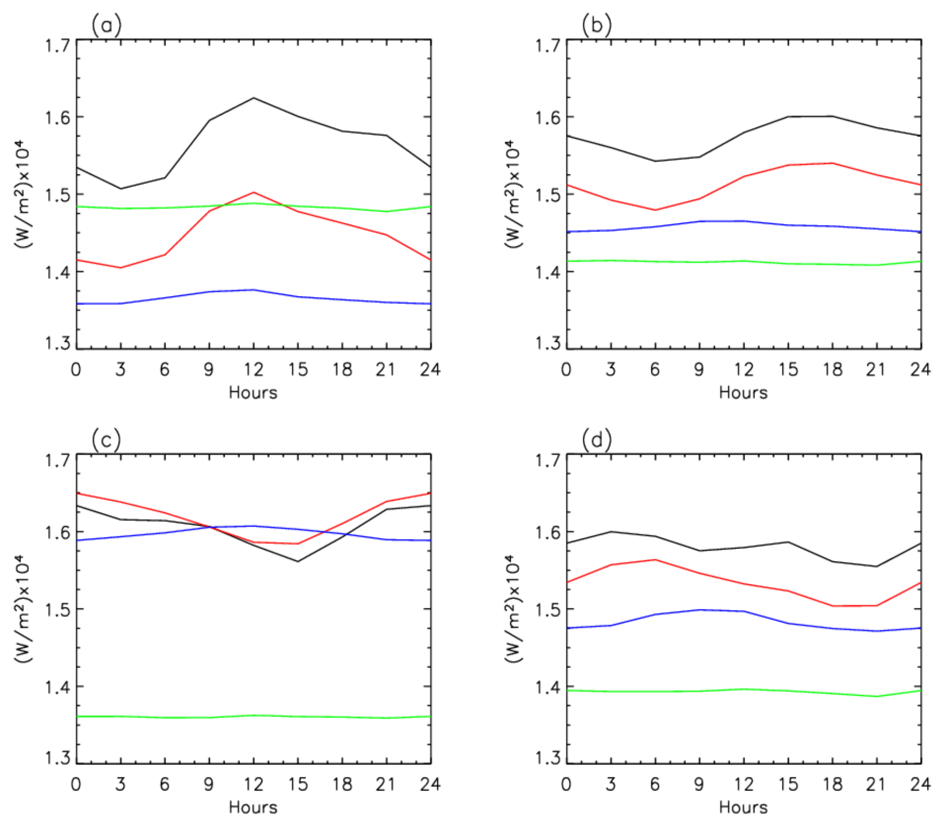

Fig. 3.— Light curves. From upper left to lower right corner: January, April, July and October 2001 for 90°, 45°, 0° and -90° inclination angles (black, red, blue and green lines respectively).

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Autocorrelation

* Rotation period: 24 hours

*January and July have are more stable.
(Polar fronts, anticiclons)

*April and October are more cloudy
(hurricanes, monsoons)

*Polar regions are more homogeneous.

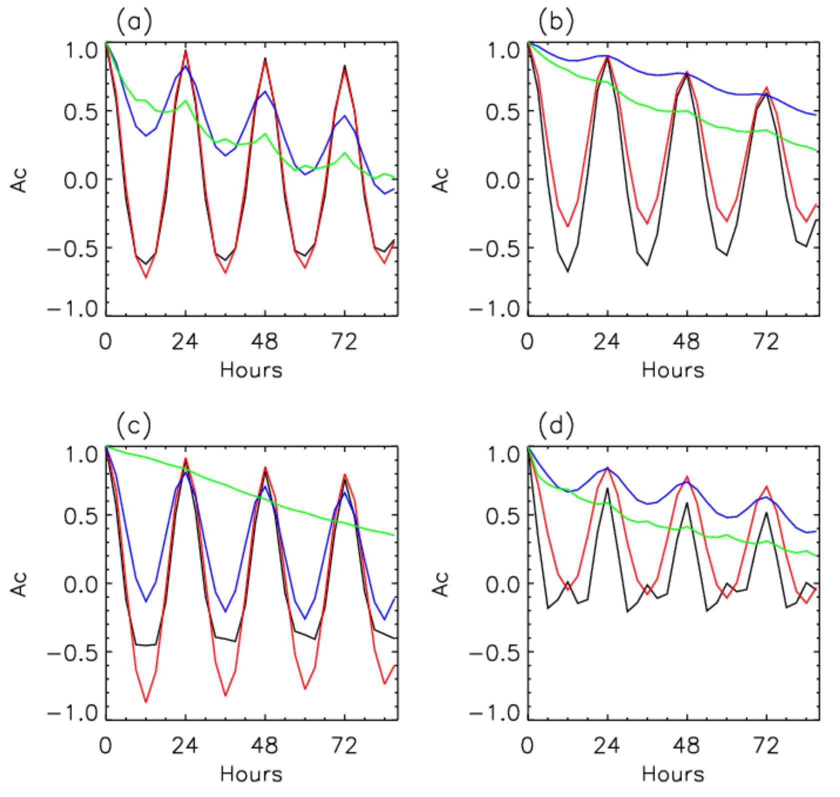

Fig. 4.— Autocorrelation.From upper left to lower right corner: January, April, July and October 2001 for 90°, 45°, 0° and -90° inclination angles (black, red, blue and green lines respectively).

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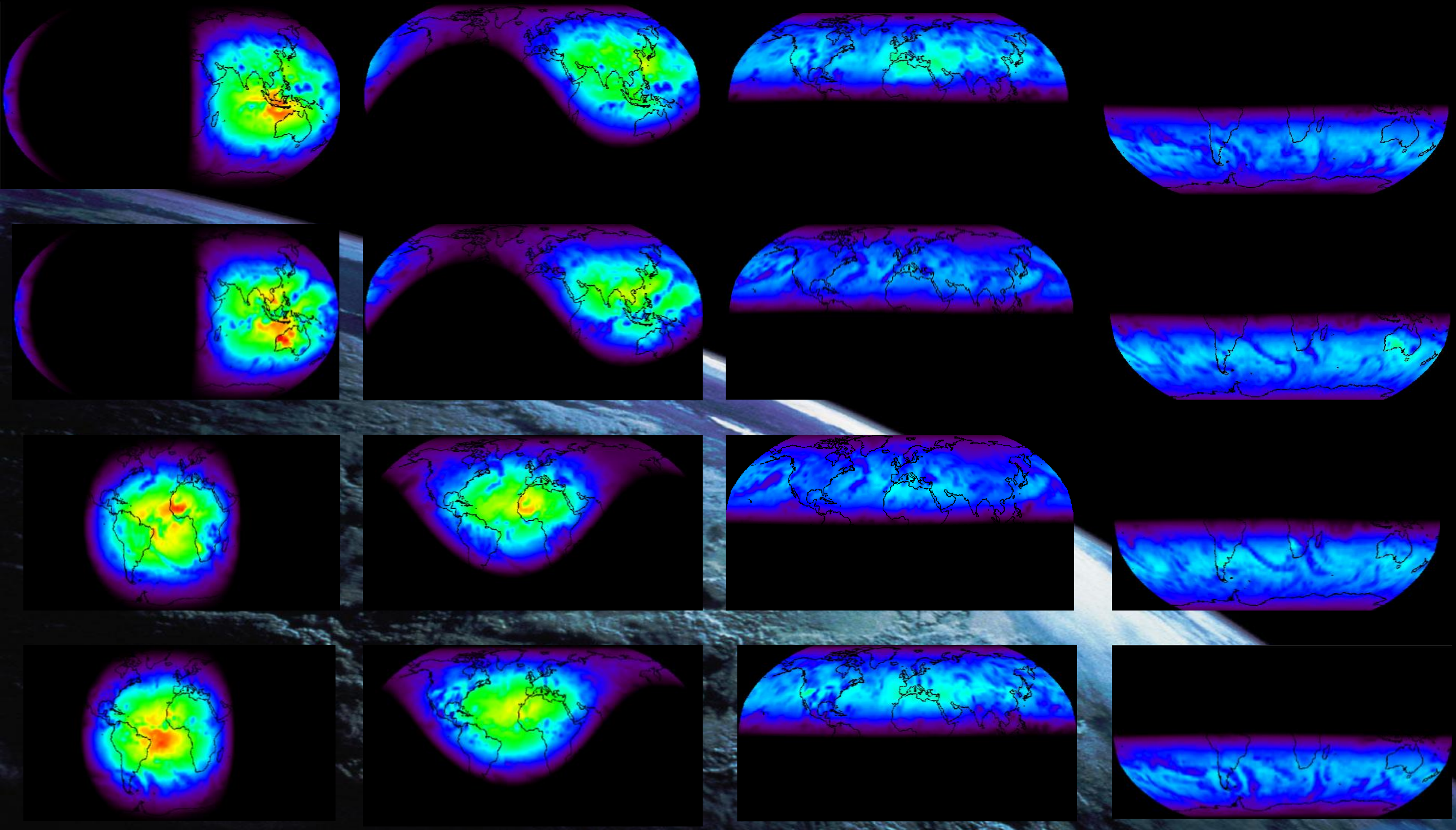

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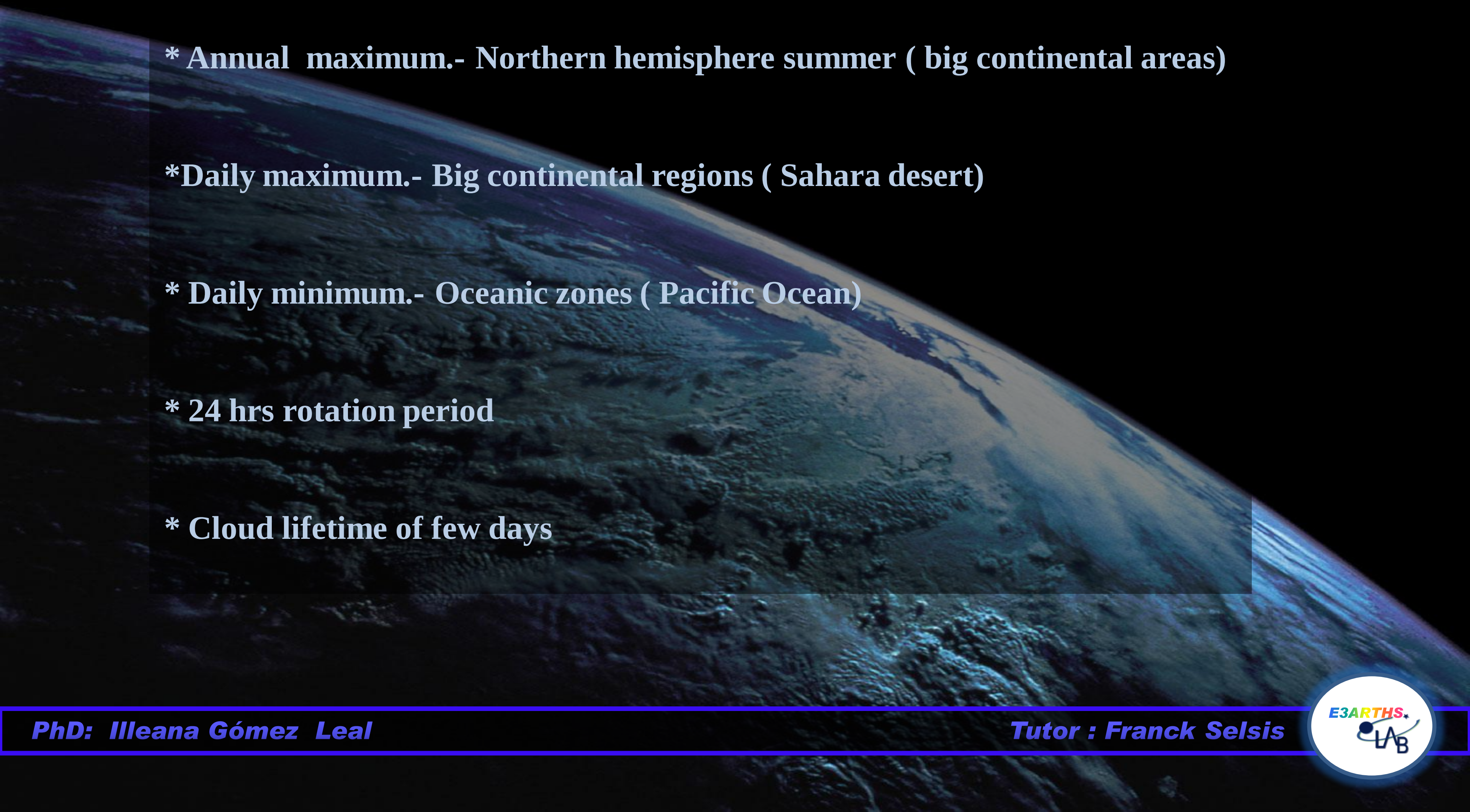
Conclusions



* Annual maximum.- Northern hemisphere summer (big continental areas)

*Daily maximum.- Big continental regions (Sahara desert)

* Daily minimum.- Oceanic zones (Pacific Ocean)

* 24 hrs rotation period

* Cloud lifetime of few days

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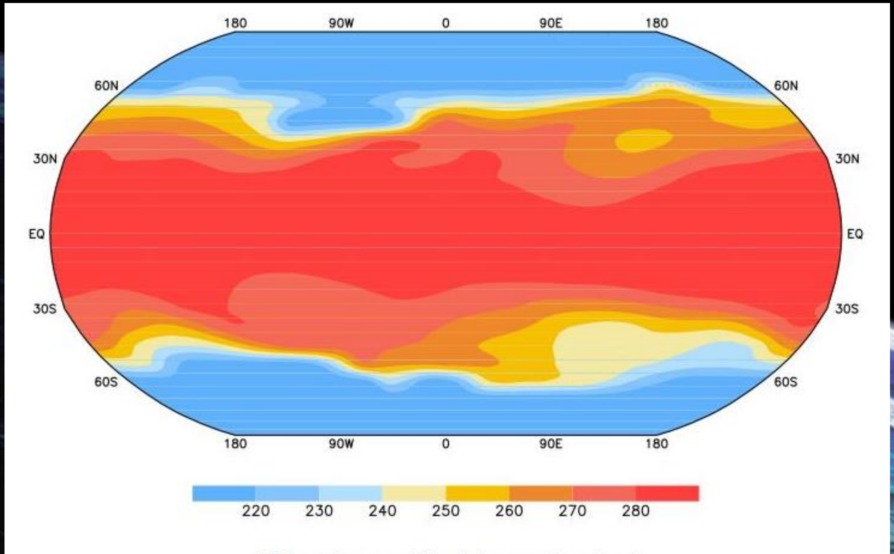
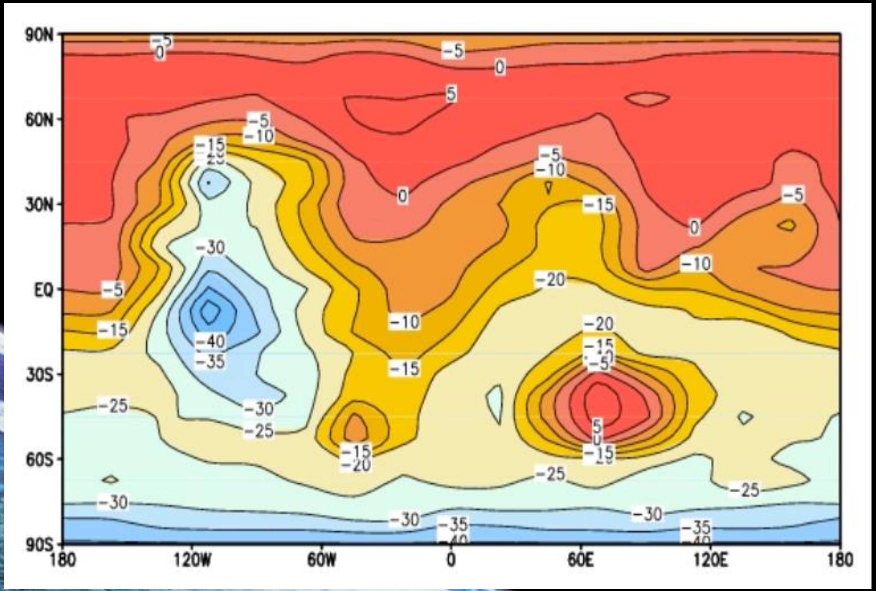
Future work …



Wordsworth, Forget et al.



Gliese 581d: Carte de température

- 5 bars CO_2
- étoile M ≠ Soleil
- rotation synchrone (toujours la même face éclairée)
- obliquité = 0°

Fig. 3 GCM simulation of early Mars. *This temperature map is a result of a Martian simulation at 4 Ga, with a 2 bar CO_2 atmosphere, including CO_2 ice clouds. F. Forget, unpublished.*

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* Bloom et al. 2005, Technical Report Series on Global Modeling and Data Assimilation 104606, 26.

*Fu et al. 1997, JAS, Vol. 54, 2799-2812.

*Gaidos E. and Williams D. M. 2004, New Astronomy vol. 406.

* Pallé et el. 2008, ApJ, Vol. 676, 1319-1329.

* Pallé, E., et al. 2003, J. Geophys. Res. D, 108, 4710.

*Rossow and Schiffer, 1999, BAMS, 80, 2261-2287.

*Selsis F. 2004, ASP Conference Series, vol 321. 170-180

* Vázquez M. et al. 2008, *The Earth as a distant planet. A Rossetta stone for the search of the Earth-like worlds.* Springer.

* Wilber et al. 1999, NASA/TP-1999-209362, 35 pp.