# Earth radiation models and Earth's climate energy imbalance

Maya Nocet-Binois

In collaboration with Alexandre Couhert, Flavien Mercier & Pascal Gegout

OSTST meeting: November 7 – November 11 2023





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Altimetry a) Earth radiation pressure modeling b) Impact of the new model on altimetry

II. Earth's Radiative Budget





Earth's Radiative Budge



#### **Orbital determination for altimetry**

Objective: Achieve an orbital radial error of less than 0.1 mm/year over 10 years at the regional scale. [1] Meyssignac et al. 2023

CNES: ZOOM software



#### **Precise Orbite Determination**



Impact of the new model on orbitograph 00000000 Earth's Radiative Budget

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#### Albedo and emissivity



Impact of the new model on orbitograph 00000000 Earth's Radiative Budget

Conclusion O O Conclusion

#### **Albedo and emissivity**



[2] KNOCKE et al. 1988

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#### **Albedo and emissivity**

Altitude altimetric satellite



Earth's Radiative Budget

Conclusion O O CENTRE NATION

#### Temporal and spatial complexity of the two sources of Earth radiation

ERA5 (reanalysis)- hourly data January 01, 2023

Thermal radiation (Longwave)

Albedo (Shortwave)



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Earth's Radiative Budget



#### **Evolution of the Earth Pressure radiation modeling**



Earth's Radiative Budget

Conclusion O O CONCENTRE NATI

# **Evolution of the Earth Pressure radiation modeling**



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#### Zoom implementation and cross-validation with external tool

#### **External software developed**

- $\vec{a} = f_r C_r \frac{A}{m} P_{tot} \vec{u}_r$
- $dP_{tot} = (F_{SW} + F_{LW}) \frac{\cos(\alpha)}{c r_{sat}^2 \pi} dA$

#### **ZOOM implementation**



Earth's Radiative Budget



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#### **ZOOM** implementation



Con	text			Earth	radi	atior	ו pre	essur	e mo	delir	ng
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# Models shift in ZOOM



Earth's Radiative Budget



# **Results : models comparison**



Earth's Radiative Budget

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#### **External validation: with the University of Bonn**

Personnal communication : Kristin Vielberg & Jürgen Kusche



Earth's Radiative Budget

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Con	text			Earth	radi	atior	i pre	ssur	e mo	deling
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#### **Altimetry satellites**

	CryoSat-2	Sentinel-6A
Operational Period	April 8, 2010 - today	November 21, 2020 - today
Inclinaison	92°	66°
Altitude	717 km	1336 km
Surface/masse	$0.012 \ m^2/kg$	$0.018 \ m^2/kg$
Draconitic period	16 months	4 months

Con	text			Earth	radi	ation	pre	ssure	modeling
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#### **Orbit determination**



Least-square optimisation

Context		Earth	radi	iatior	n pre	essur	e modeling	Impac	t of	the n	iew	mod	el on orbitography	Earth's Radiative Budget C	0
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#### CryoSat-2



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Earth's Radiative Budget



#### CryoSat-2



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Cor	ntext			Earth	radi	iatior	n pre	essur	e modeling	Impa	ct of	the r	new	mod	el on orbitograp	bhy
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Earth's Radiative Budget



#### CryoSat-2



Context	Earth radiation pressure modeling	Impact of the new model on orbitography	Earth's Radiative Budget	Conclusion
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### **Empirical forces Sentinel-6A**



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#### Does our model augmentation meet the goal ? (0,1 mm/year over ten years regionally)





Context	Earth radiation pressure modeling	Impact of the new model on orbitography	Earth's Radiative Budget	Conclusion
0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	• • •	0 0

#### Earth Energy Imbalance



Context	Earth radiation pressure modeling	Impact of the new model on orbitography	Earth's Radiative Budget	Conclusion
0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	• • •	0 0

#### **Earth Energy Imbalance**



Earth's Radiative Budget



#### Ajisai : Experimental Geodetic Satellite (EGS)

Operational Period : August 1986 - today

Orbite

 Altitude : 1500 km
 Nearly circular
 Inclinaison : 50°

Satellite Spherical 318 miroirs Diameter 2.15 m

Grasse

31 stations

Earth's Radiative Budget ○ ○ ●



#### **Preliminary results: annual correction of Earth fluxes**

#### $f_{r} = \text{CFPIRA error (\%)}$



 $\vec{a} = \mathbf{f_r} \ C_r \ \frac{A}{m} \ P_{tot} \vec{u}_r$ 

SW flux error (W/m2)

2019

2018

Years

2020

ERA5 CERES

Con	text			Earth	radi	atior	n pre	ssur	e mo	odelin	g
0	0	0	0	0	0	0	0	0	0		

Earth's Radiative Budget



New model of the Earth's radiation pressure based on observations

 $\vec{a} = f_r C_r \frac{A}{m} P_{tot} \vec{u}_r$ 

Orbit determination

Improved force model on satellite altimeter

. Empirical force

.  $f_r$  is not released

Dynamic parameterisation .  $f_r$  is released

#### Scientific question

More accurate measurement of sea levels

Better knowledge of the outgoing flux of the Earth and therefore of the Earth's energy balance

Cont	text			Earth	radi	atior	n pro	essur	e mo	odeling	Impac	t of t	he r	new	mod	el or	n orbitography	Earth'	s Rac	diative Budget	Conclu	sion	
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#### Conclusion

This study has accomplished the following key outcomes during my internship:

- 1. Highlighting the need for **enhanced Earth radiation pressure modeling** : The study confirm the necessity for an improved model in understanding Earth radiation pressure.
- **2. Refined model alignment with general objective** : The newly developed model aligns with the overarching goal of achieving a regional precision of 0.1 mm/year over a 10-year span.
- **3. Feasibility of laser-based flux recalibration** : The study demonstrated the feasibility of using laser technology to recalibrate flux measurements, offering promising avenues for measurement refinement.
- 4. Emphasizing the call for further research and Ph.D. proposal

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