# Non-gravitational force modelling for POD of altimetry satellites

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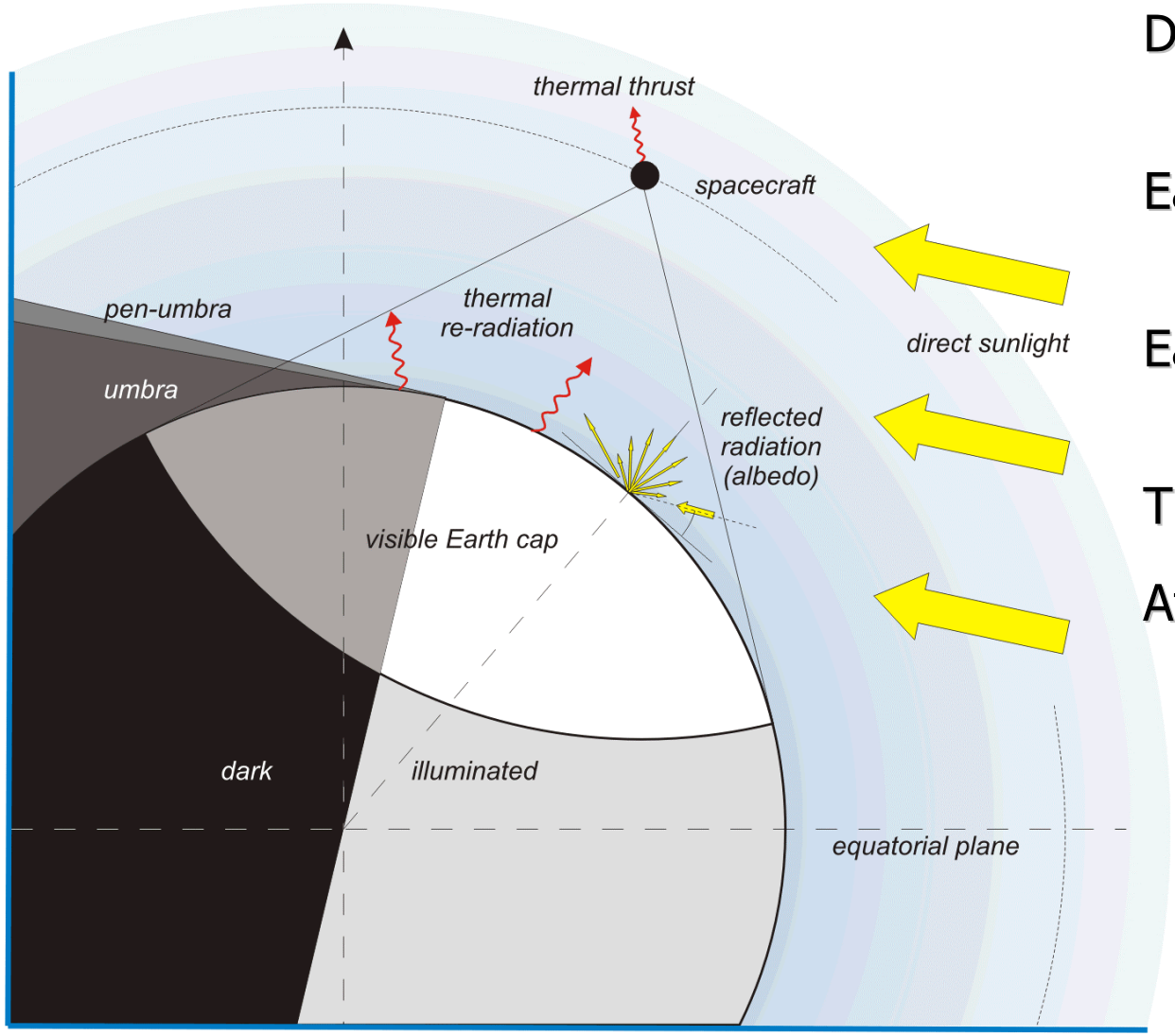
# Types of non-gravitational forces




- Direct solar radiation pressure
- Earth albedo radiation pressure
- Earth infrared radiation pressure
- Thermal reradiation
- Atmospheric drag

# In general

Accelerations depend on:

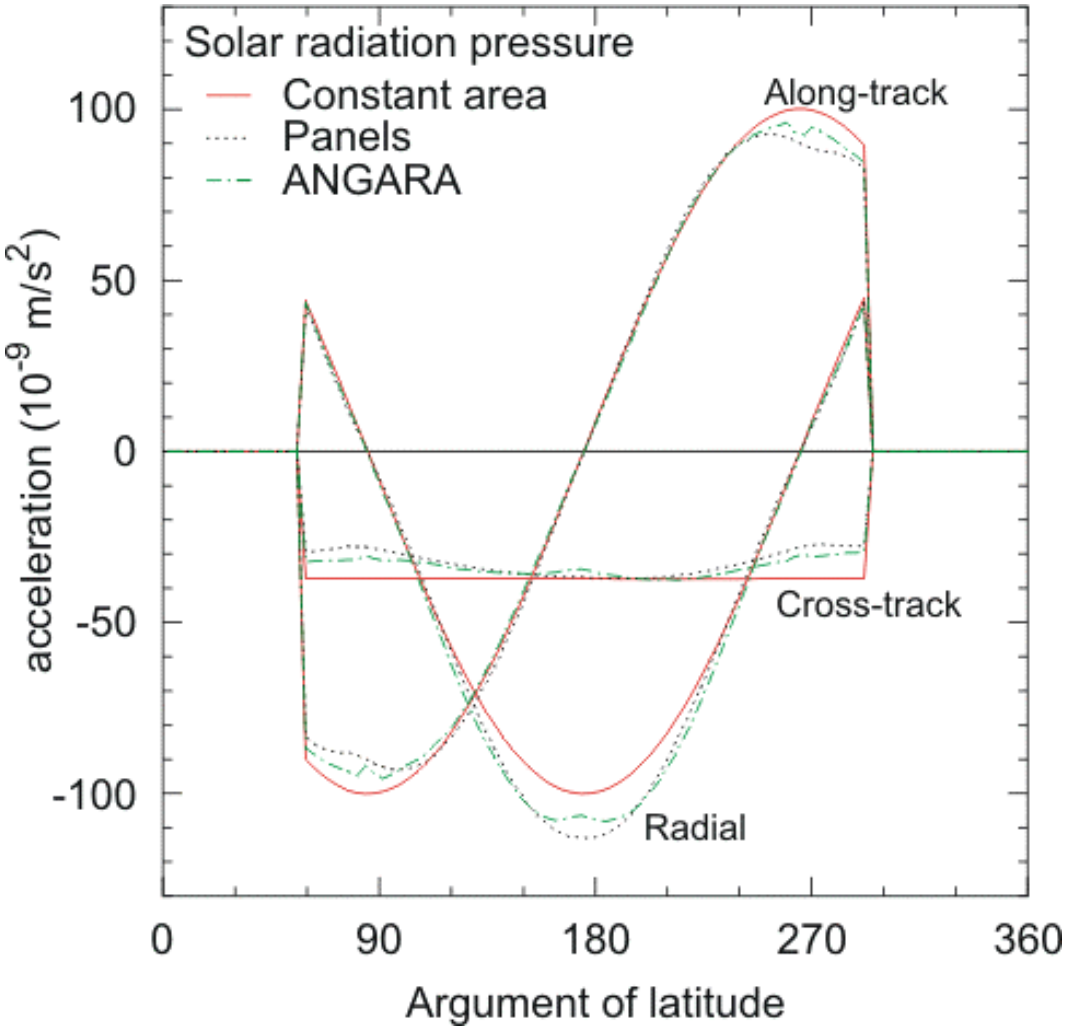
- Satellite surface geometry
- Satellite surface and particle/surface interaction properties (reflectivity, temperature, etc.)
- Space environment properties (radiation intensity, atmospheric density)

Sensitivity of satellite orbits to these perturbations determined by area to mass ratio A/m

- Smaller, lighter satellites are generally more sensitive to non-gravitational perturbations than larger, heavier ones
- ERS-2 is more sensitive than Envisat, TOPEX/Poseidon is more sensitive than Jason-1

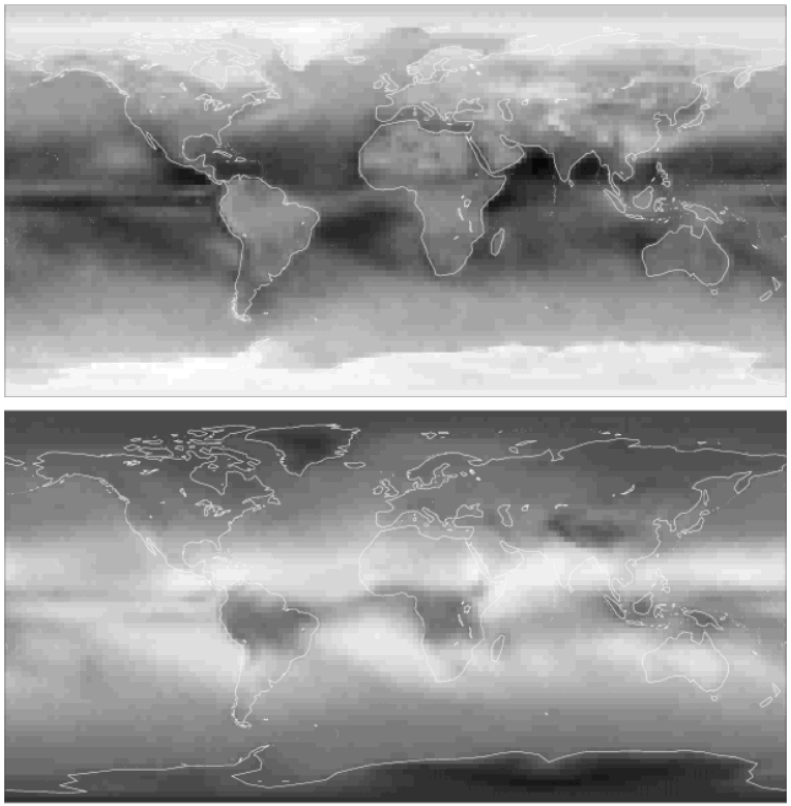
# Direct solar radiation pressure

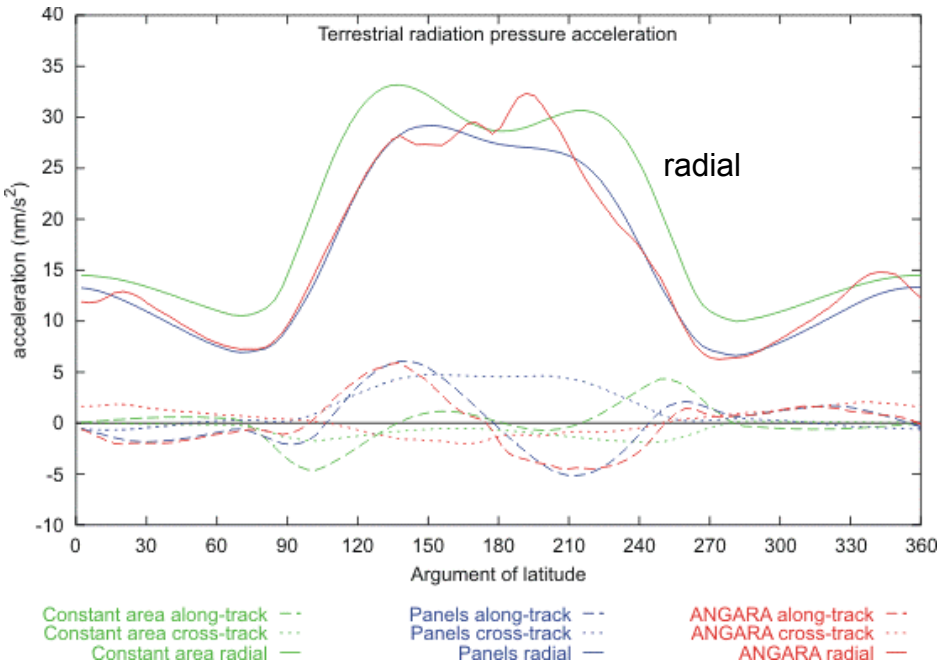
- Radiation source (Sun) very simple to model
- Satellite surface reflectivity properties provide some difficulty



# Earth albedo and infrared radiation pressure

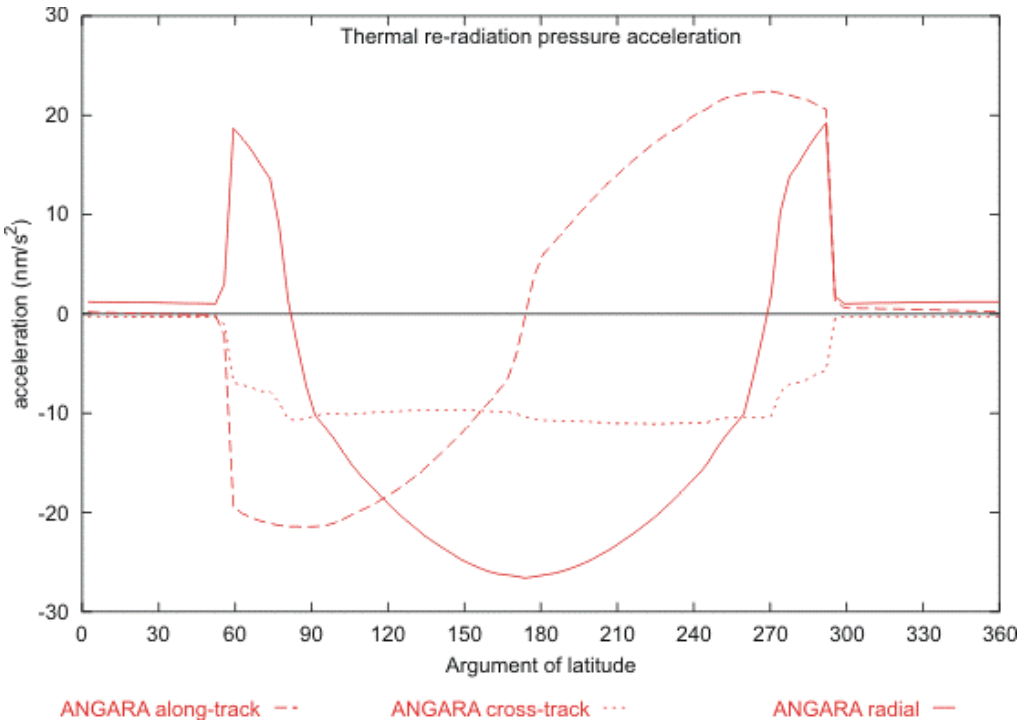
- Albedo and infrared radiation depends on surface coverage (ice, clouds, ocean, vegetation), surface temperature, etc.
- An approximate model (latitude bands) is usually sufficient for POD





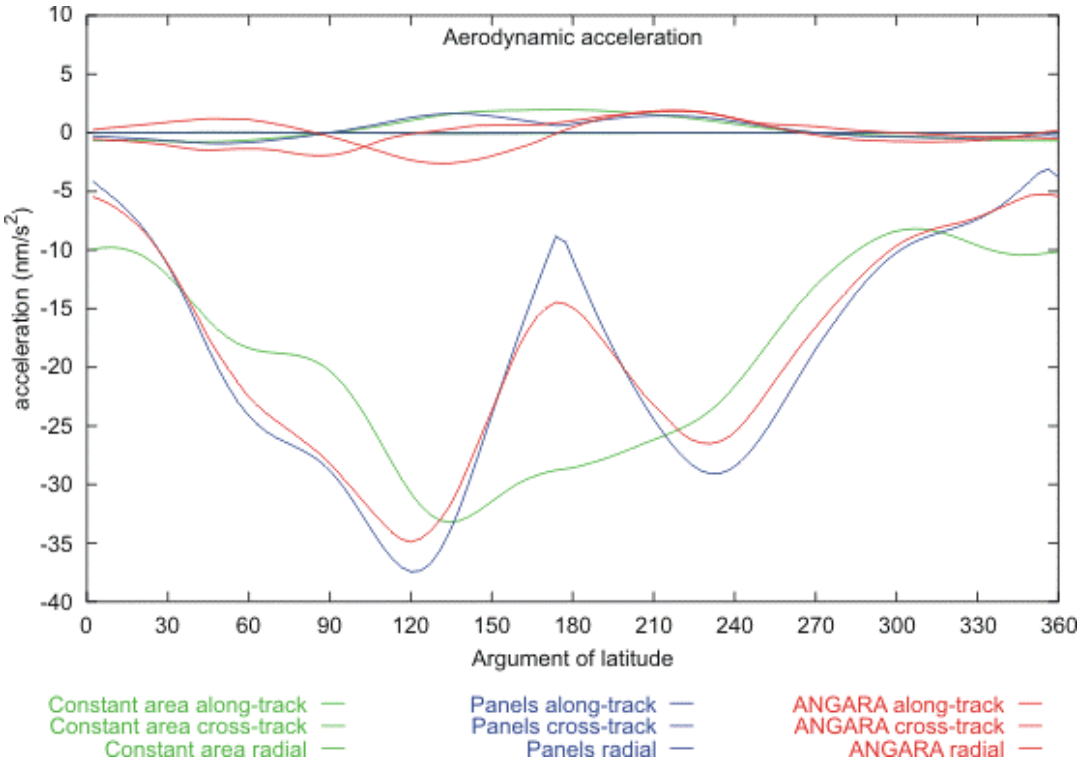
# Satellite thermal reradiation force

- Highly-detailed surface properties and temperature information, and complicated computations are required
- Usually not modeled, or using only a very basic model

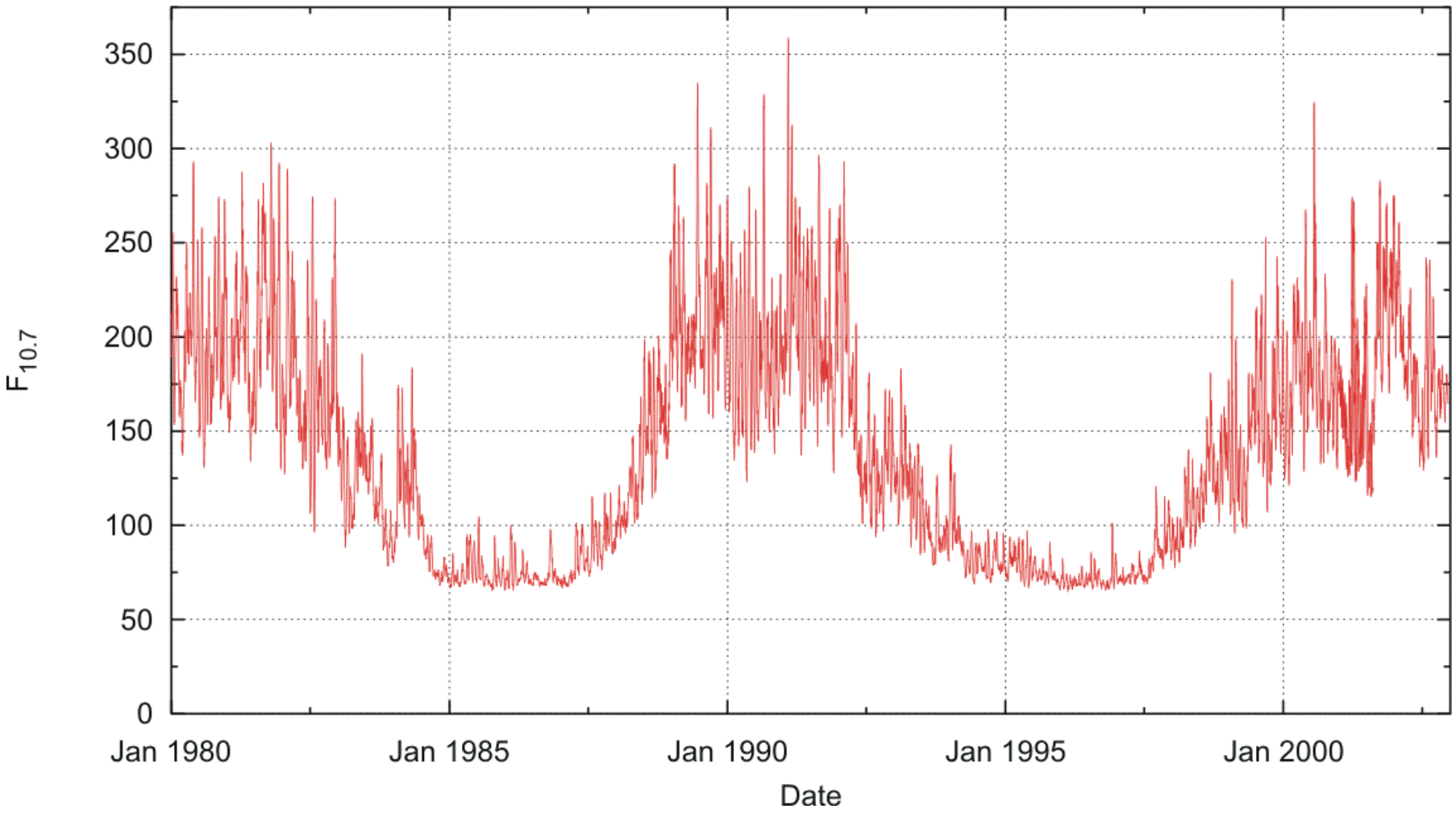


# Aerodynamic drag

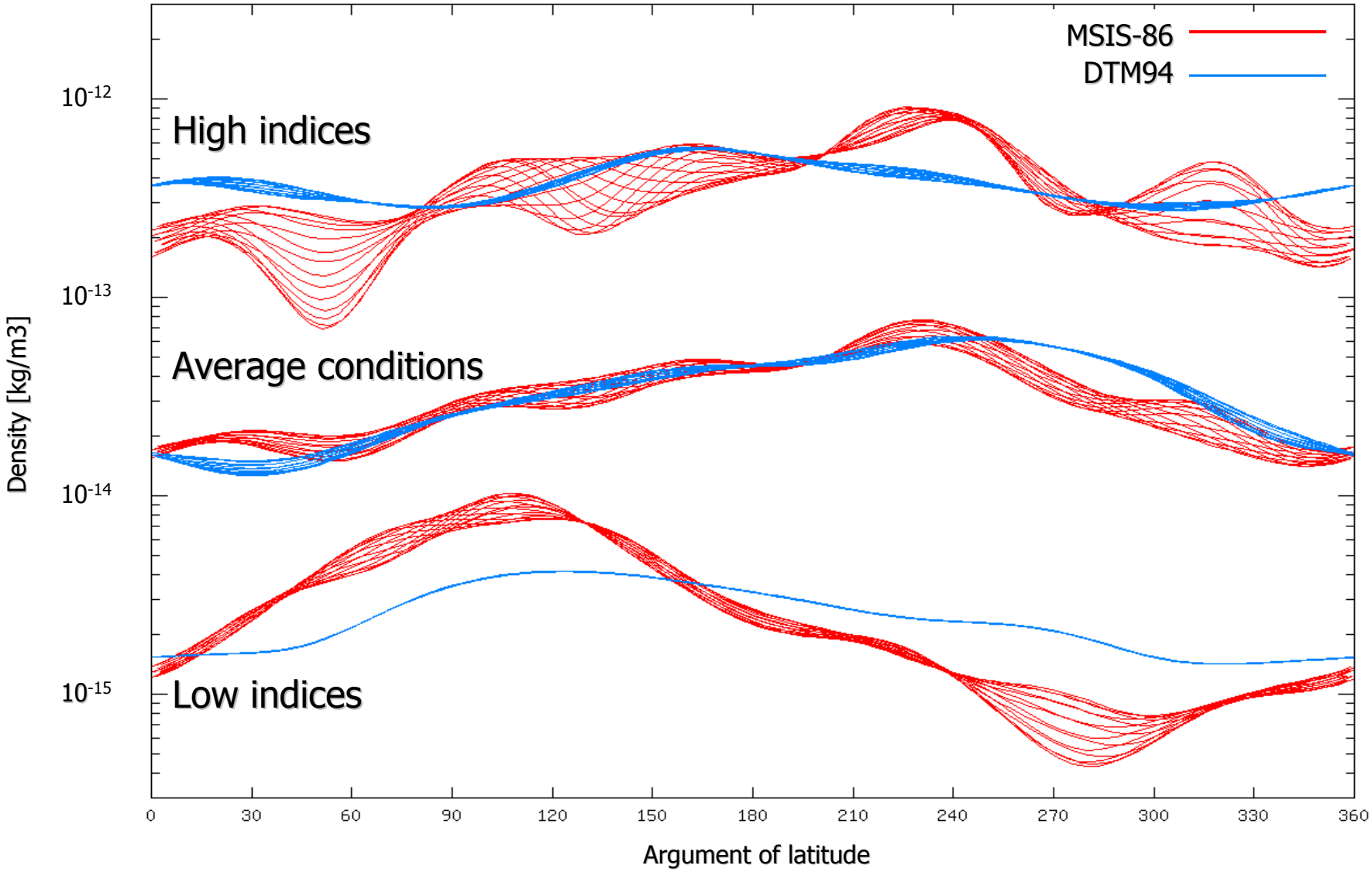
- Takes away energy from the orbit: large perturbation
- Large uncertainties from density models
- Changes in satellite attitude, solar array rotation also make things more complex

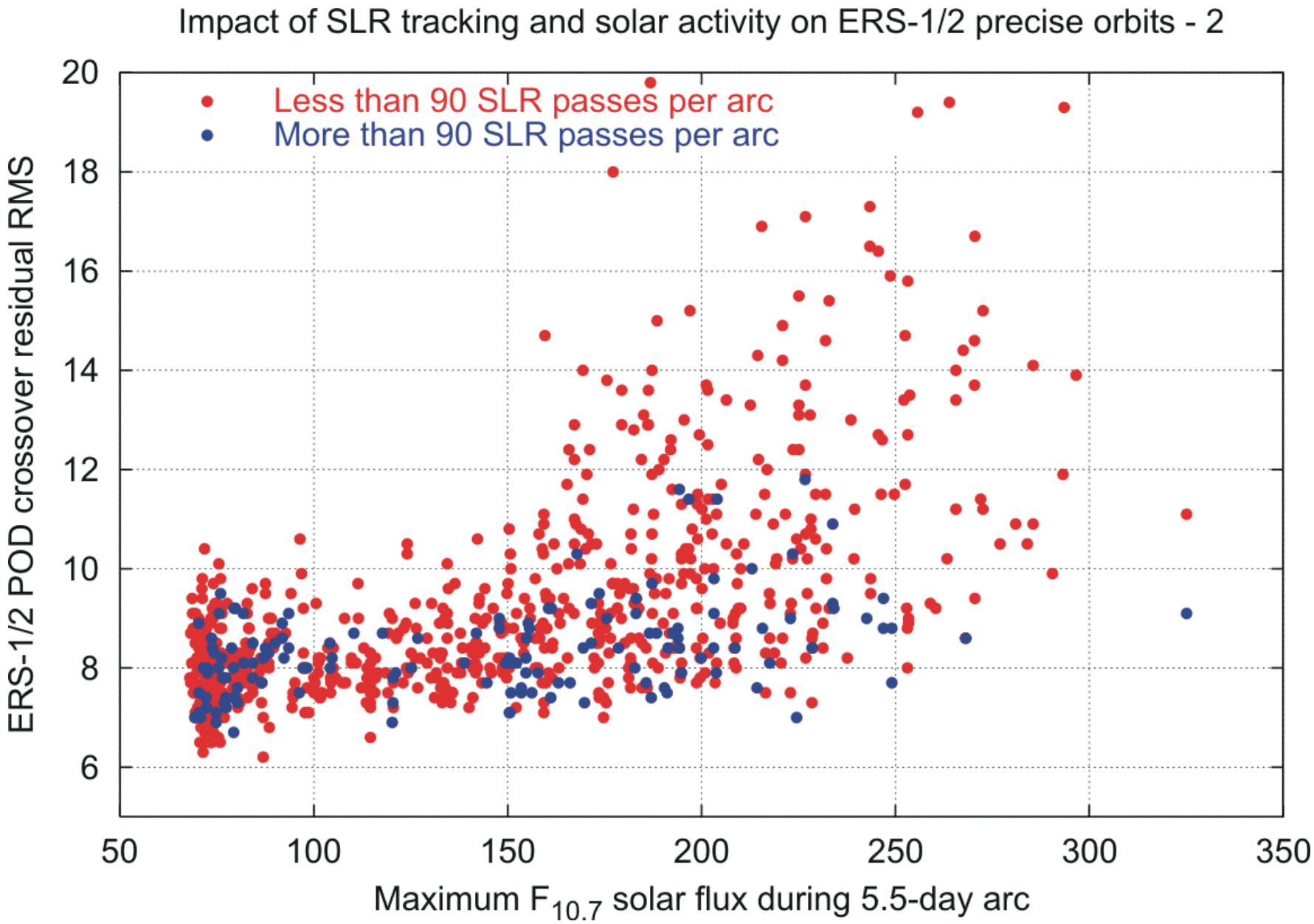


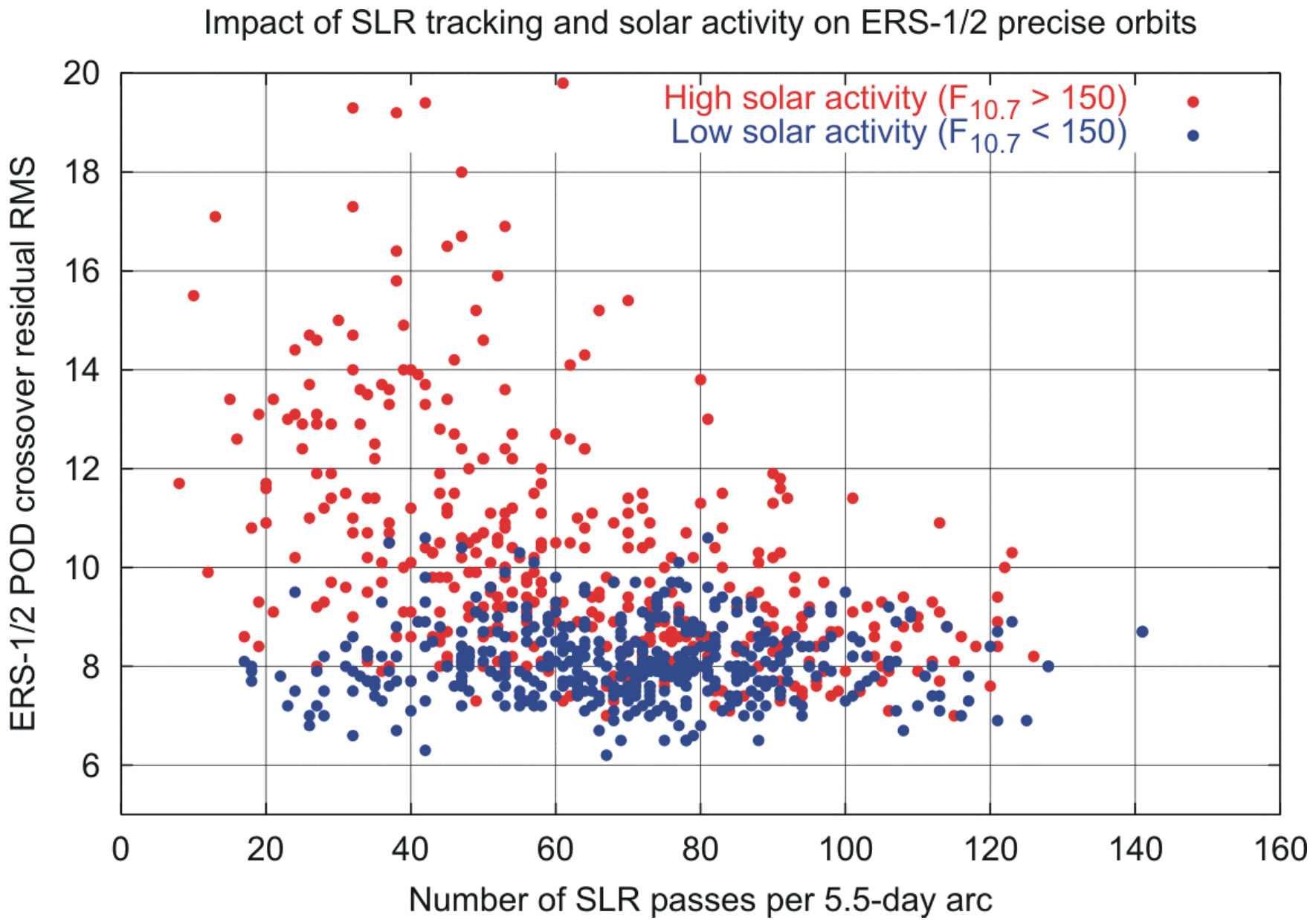
# Solar activity variations



# Atmospheric density along ERS-2 orbits




Impact of SLR tracking and solar activity on ERS-1/2 precise orbits - 2
Less than 90 SLR passes per arc
More than 90 SLR passes per arc
ERS-1/2 POD crossover residual RMS
Maximum $F_{10.7}$ solar flux during 5.5-day arc
20
18
16
14
12
10
8
6
50
100
150
200
250
300
350


Impact of SLR tracking and solar activity on ERS-1/2 precise orbits
High solar activity ($F_{10.7}$ > 150)
Low solar activity ($F_{10.7}$ < 150)
ERS-1/2 POD crossover residual RMS
Number of SLR passes per 5.5-day arc
20
18
16
14
12
10
8
6
0
20
40
60
80
100
120
140
160

# Conclusions / outlook

- Drag perturbations are the largest non-gravitational error source in POD of altimetry satellites at the altitude of ERS/Envisat or lower
- A period of low solar activity coincides with the time-frame of most of the GAMBLE missions (2006)
- When dense tracking is available (for example GPS or DORIS), force model error might be avoided by using reduced-dynamic or kinematic techniques
- Low-altitude altimeter missions with precision tracking might contribute to improvement of density models in the future. Constellations are especially interesting in that respect.