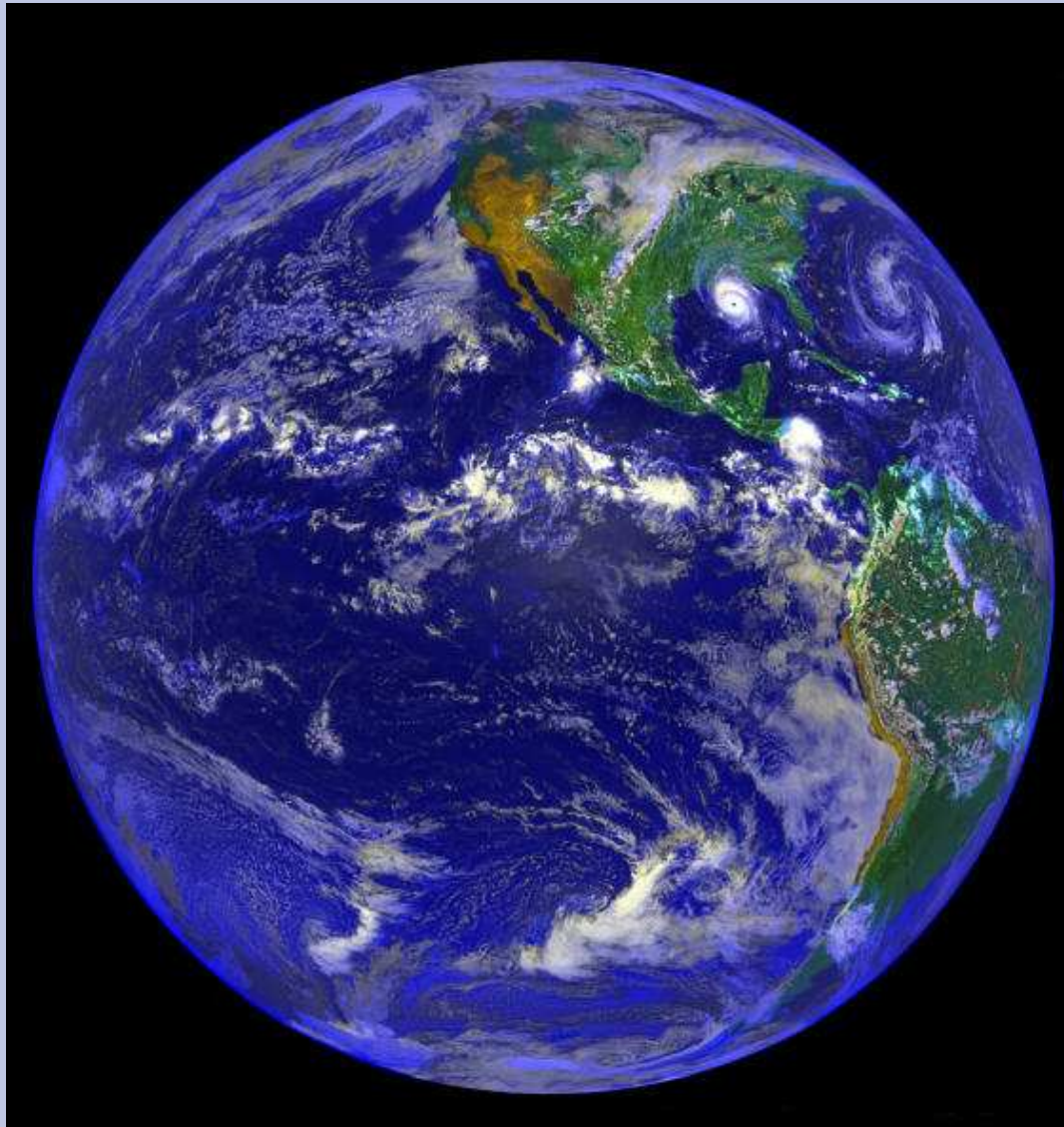


Systemy telemetrii satelitarnej

PRARE, DORIS

Zagadnienia:

- Wstęp – monitorowanie Ziemi
- Opis systemu PRARE
 - segment pokładowy PRARE
 - sygnał PRARE
 - stacje anteny naziemne
- Funkcjonowanie systemu PRARE
- Pomiar odległości i szybkości satelity
- Produkt PRARE, dostępność danych



**Widok Ziemi
z przestrzeni kosmicznej**

Względne rozmiary Ziemi, powłoki atmosferycznej, ...

$R := 6370.140$ km równikowy promień Ziemi

$T := 20$

wysokość atmosfery

$$\frac{T}{R} \cdot 100 = 0.314$$

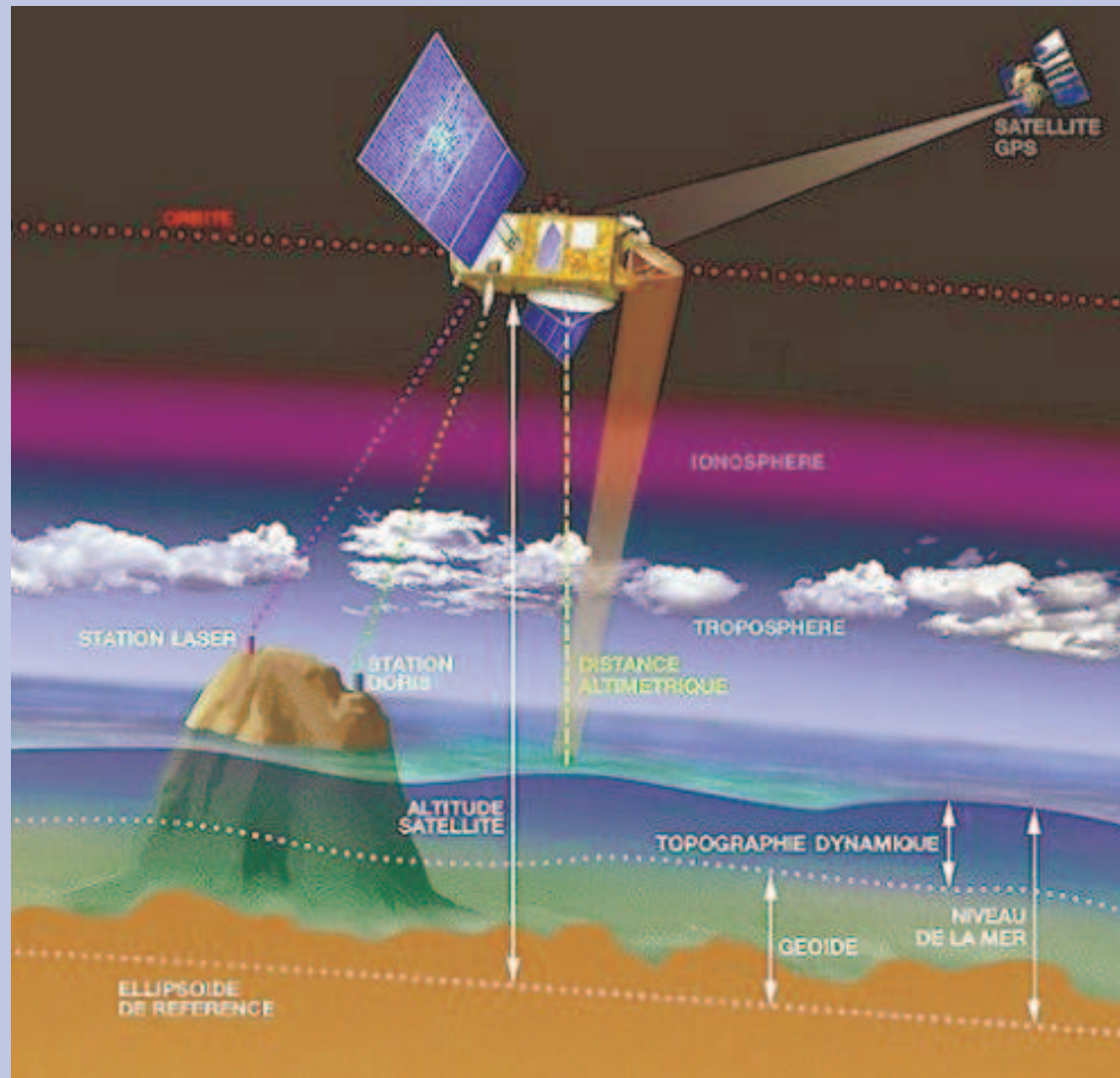
$L := 3$

głębokość pod pow. Ziemi

W skali pomarańcza o promieniu 5 cm

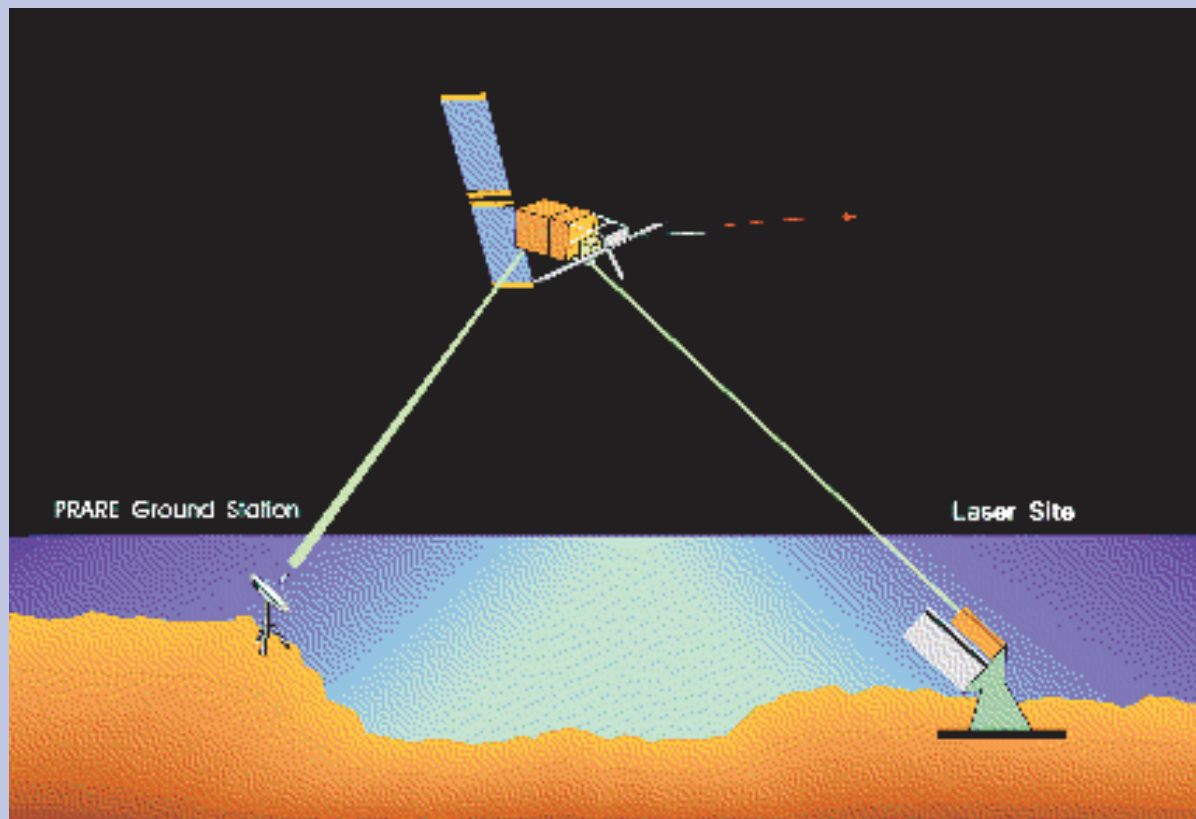
$P := 5$

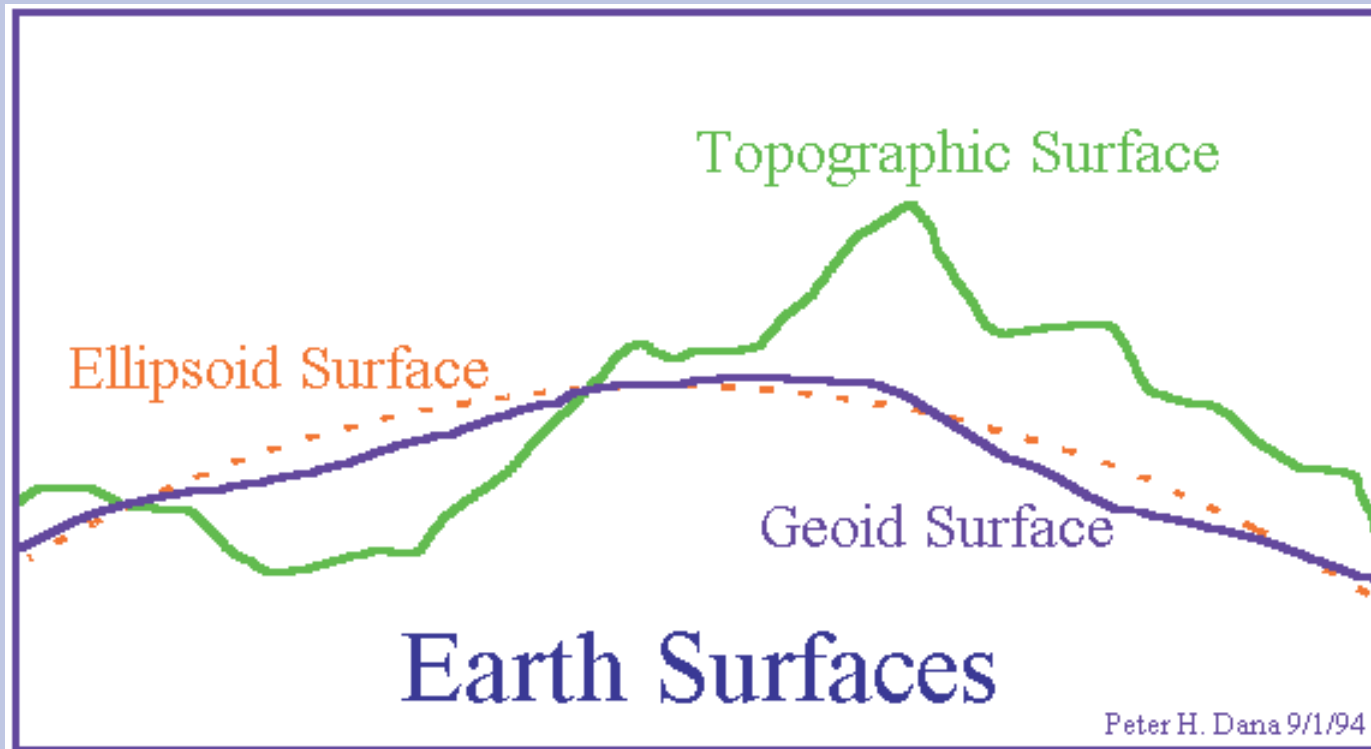
$$TL_p := (T + L) \cdot \frac{P}{R} \quad TL_p = 0.018 \quad \text{cm}$$



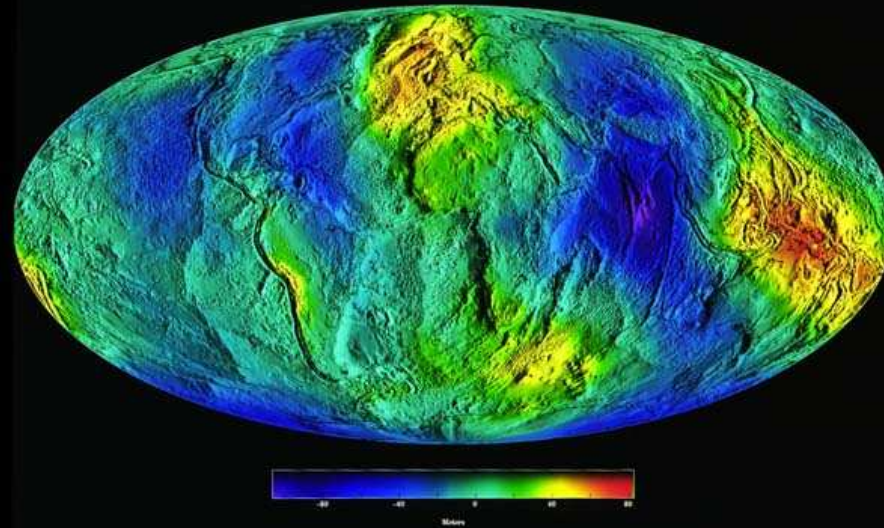
Satelitarne monitorowanie Ziemi

Obserwacja SSZ: wyznaczenie odległości i szybkości radialnej

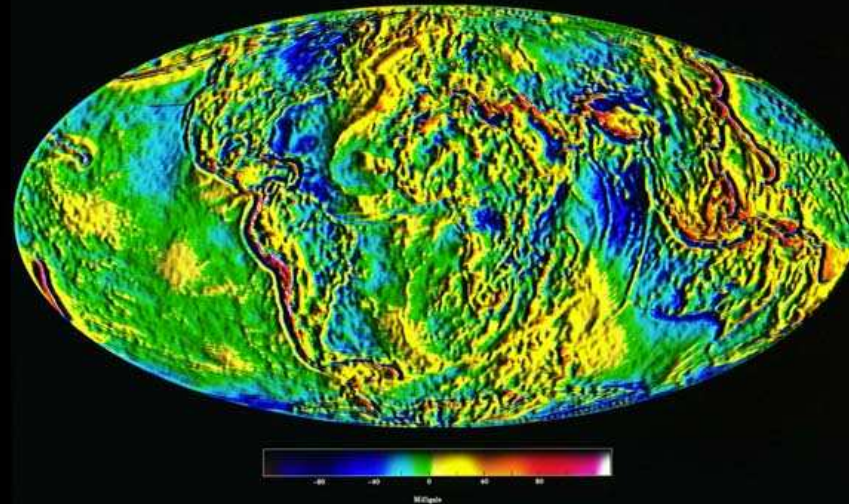


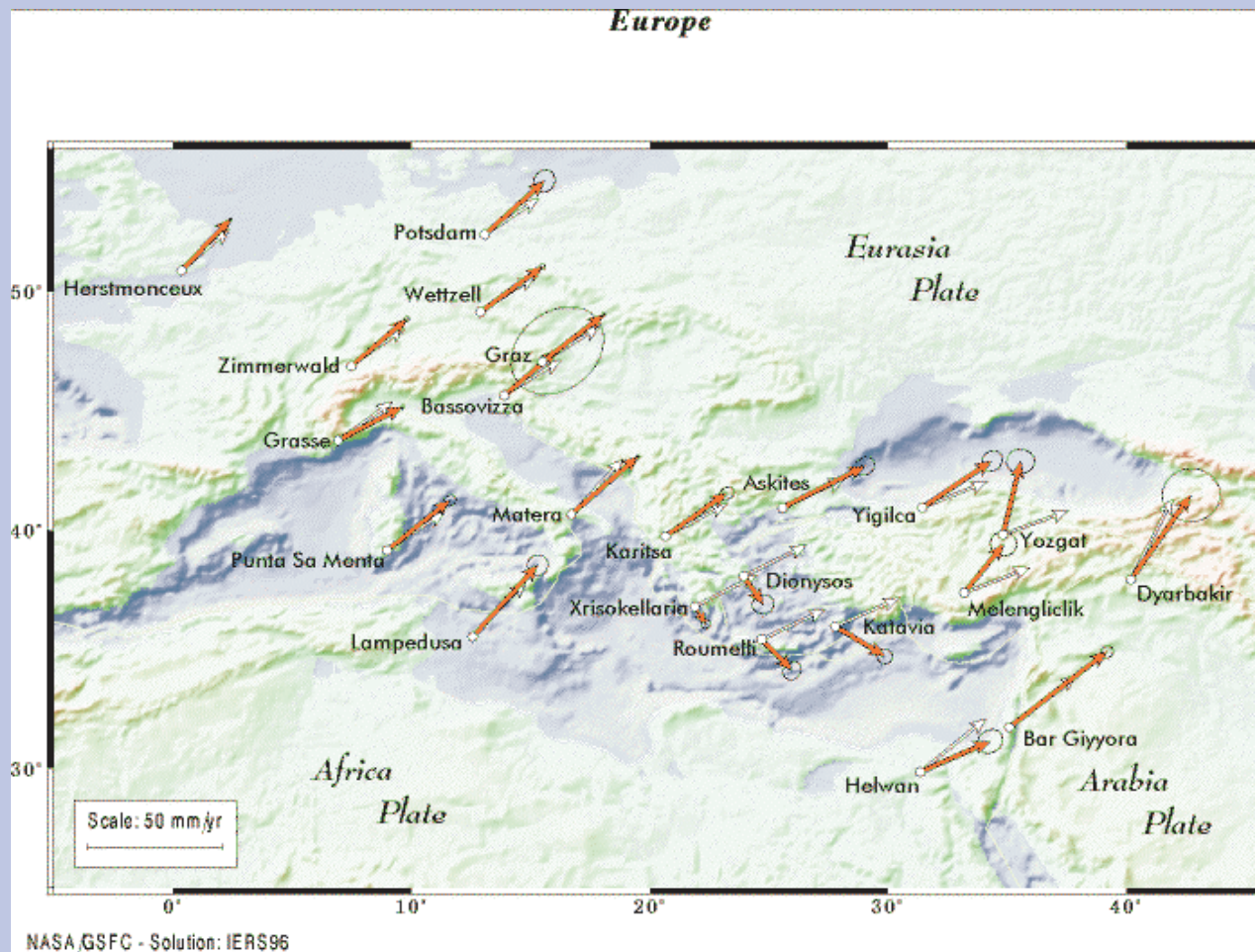


GEOID OF THE EARTH
over shaded topographic relief

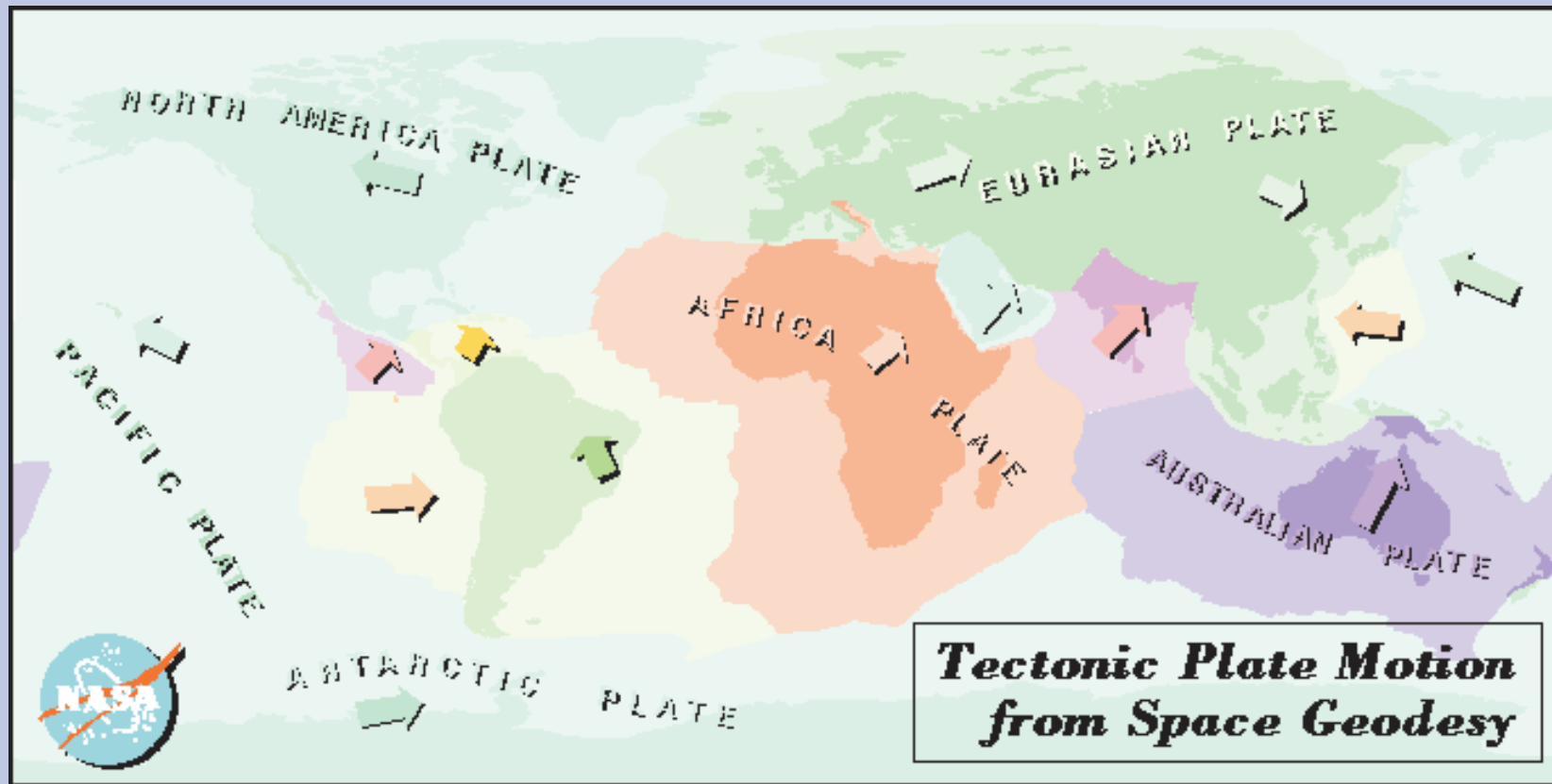


GRAVITY ANOMALIES OF THE EARTH

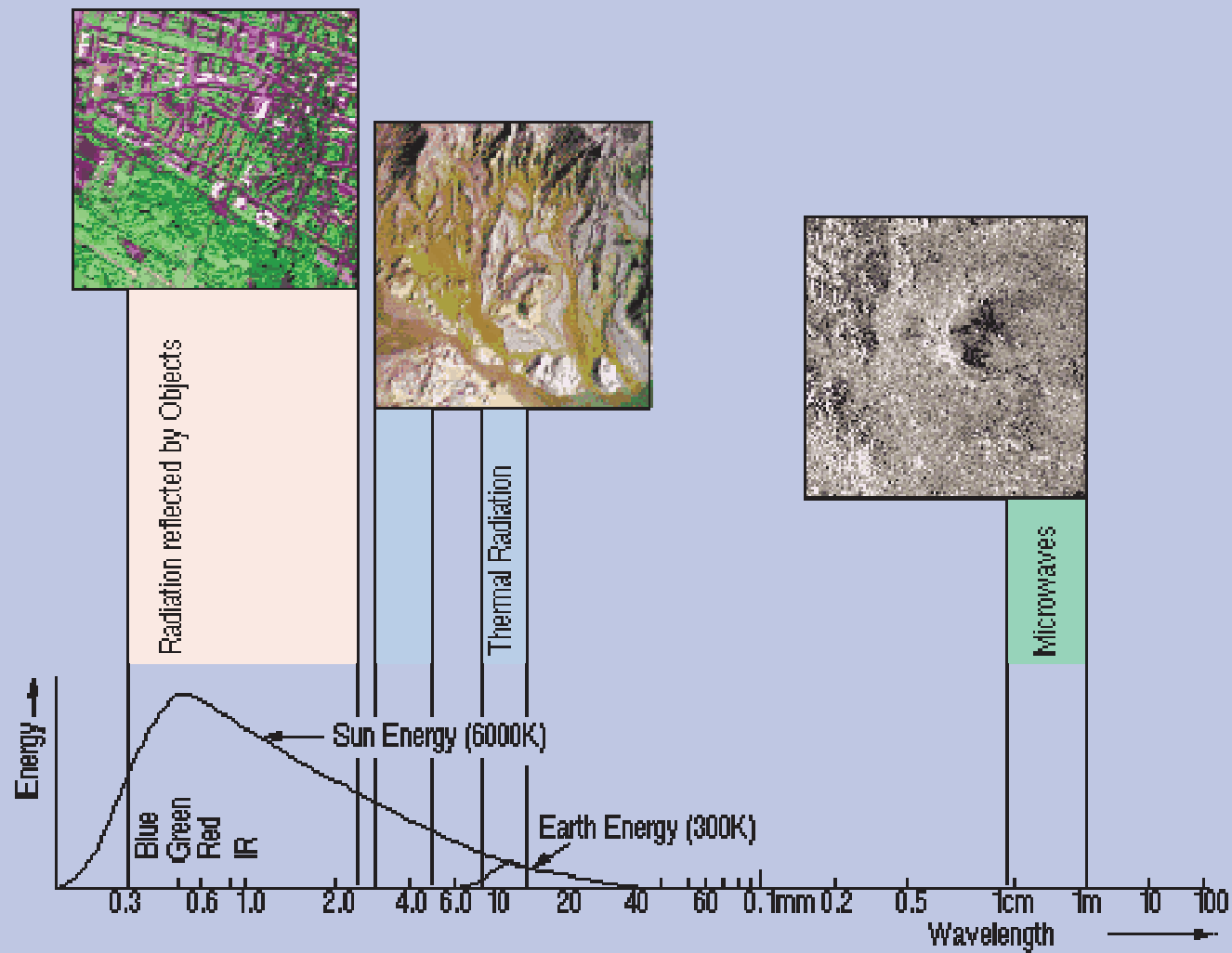


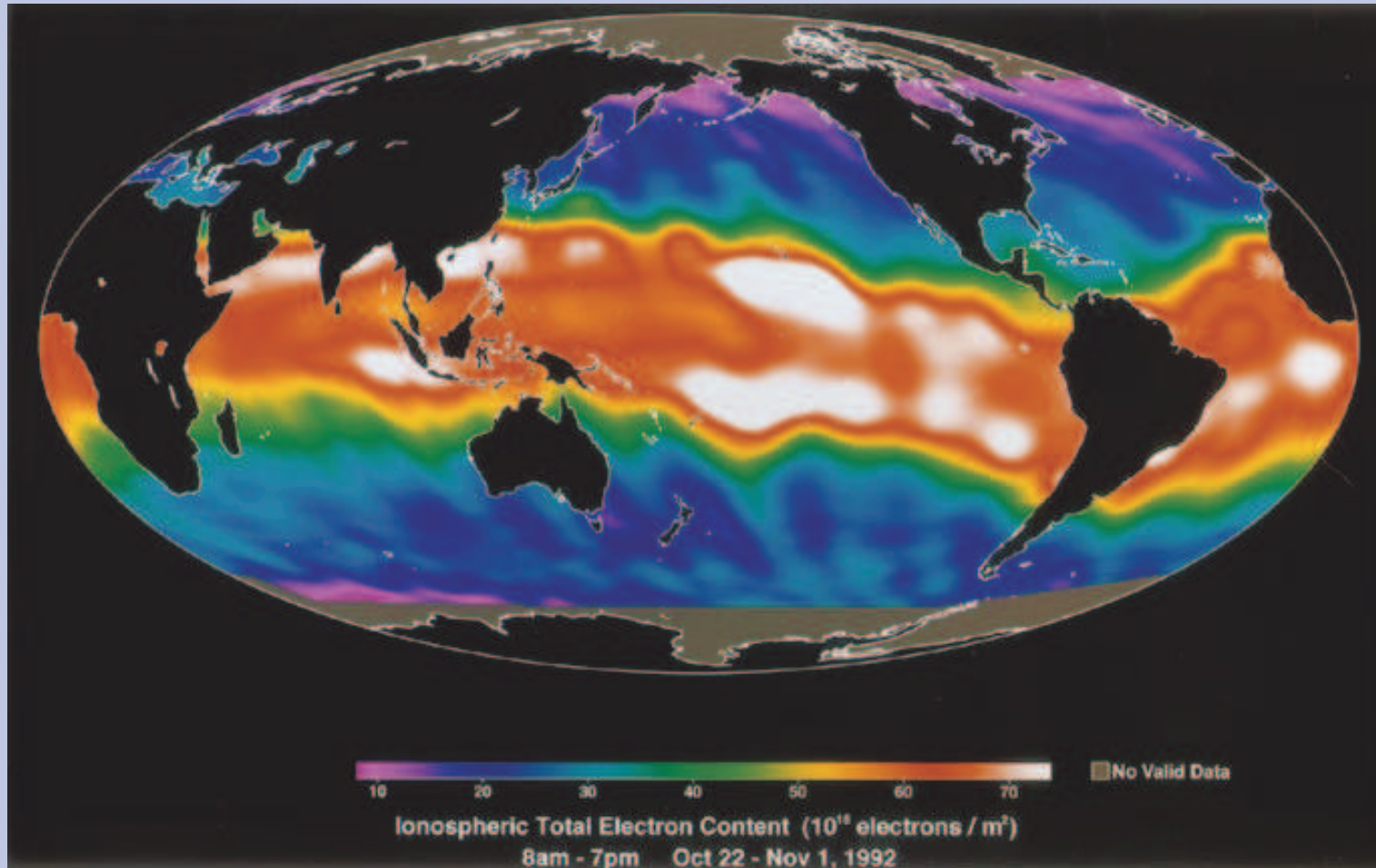


Przemieszczenia stacji obserwacyjnych



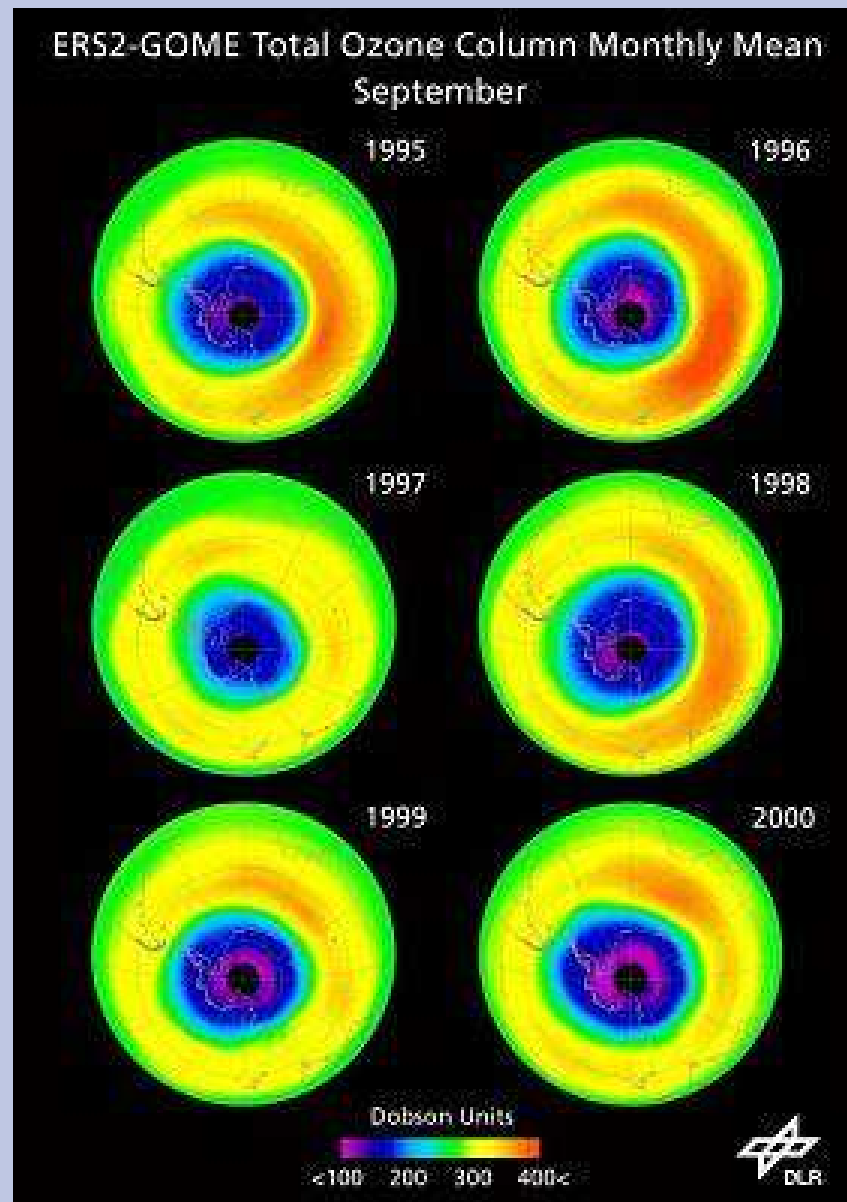
Ruch płyt tektonicznych





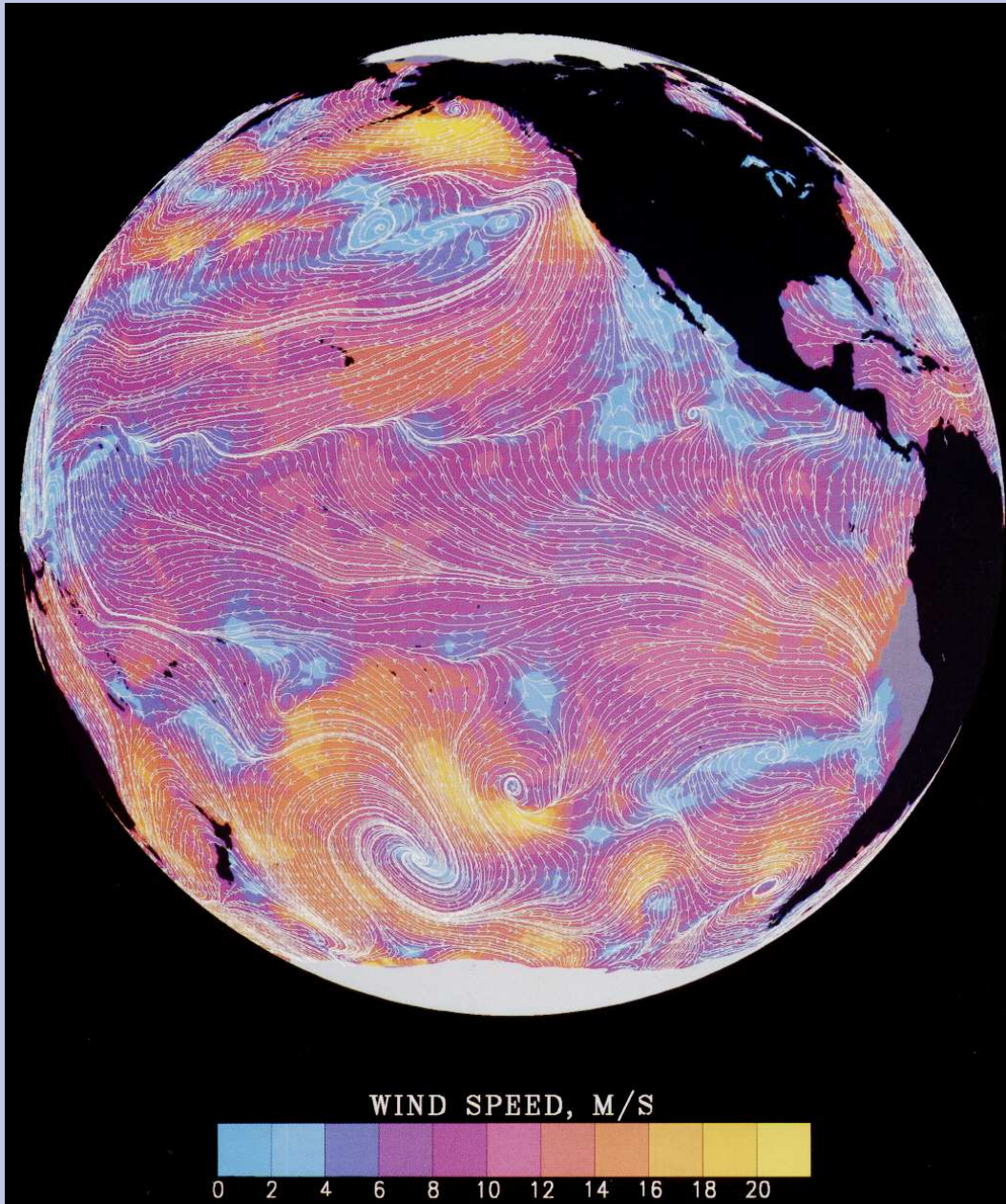
Monitorowanie jonosfery

Zawartość ozonu w atmosferze Ziemi



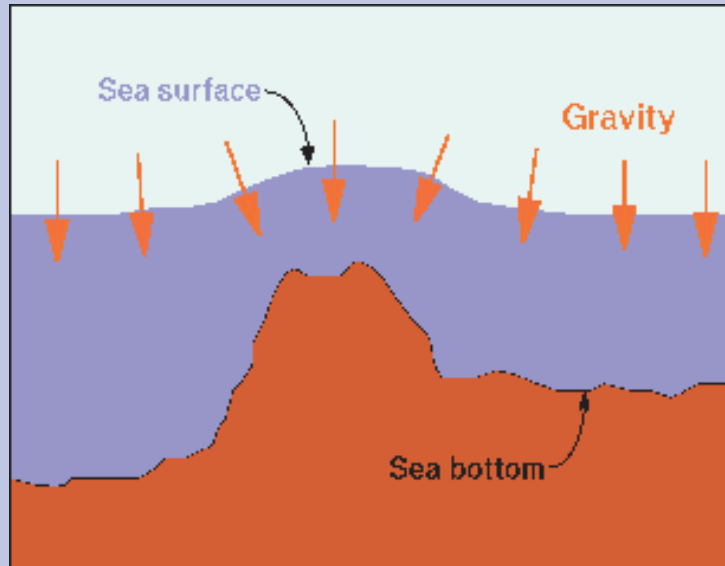


Obserwacje zachmurzenia

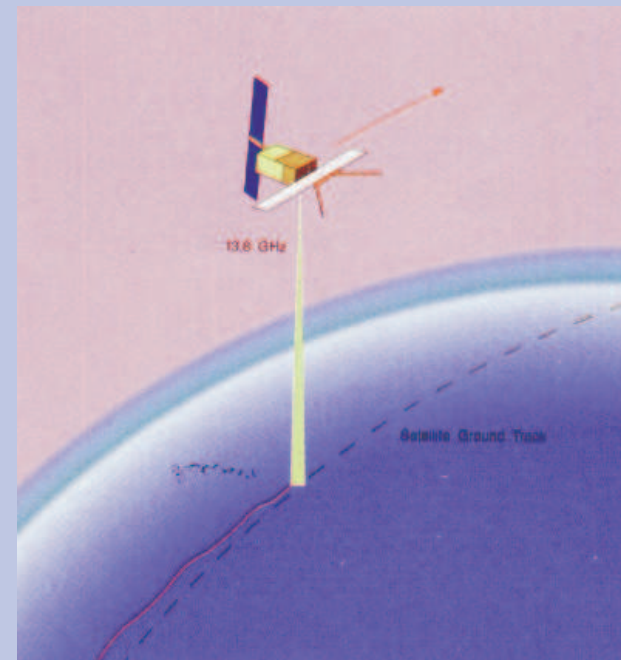


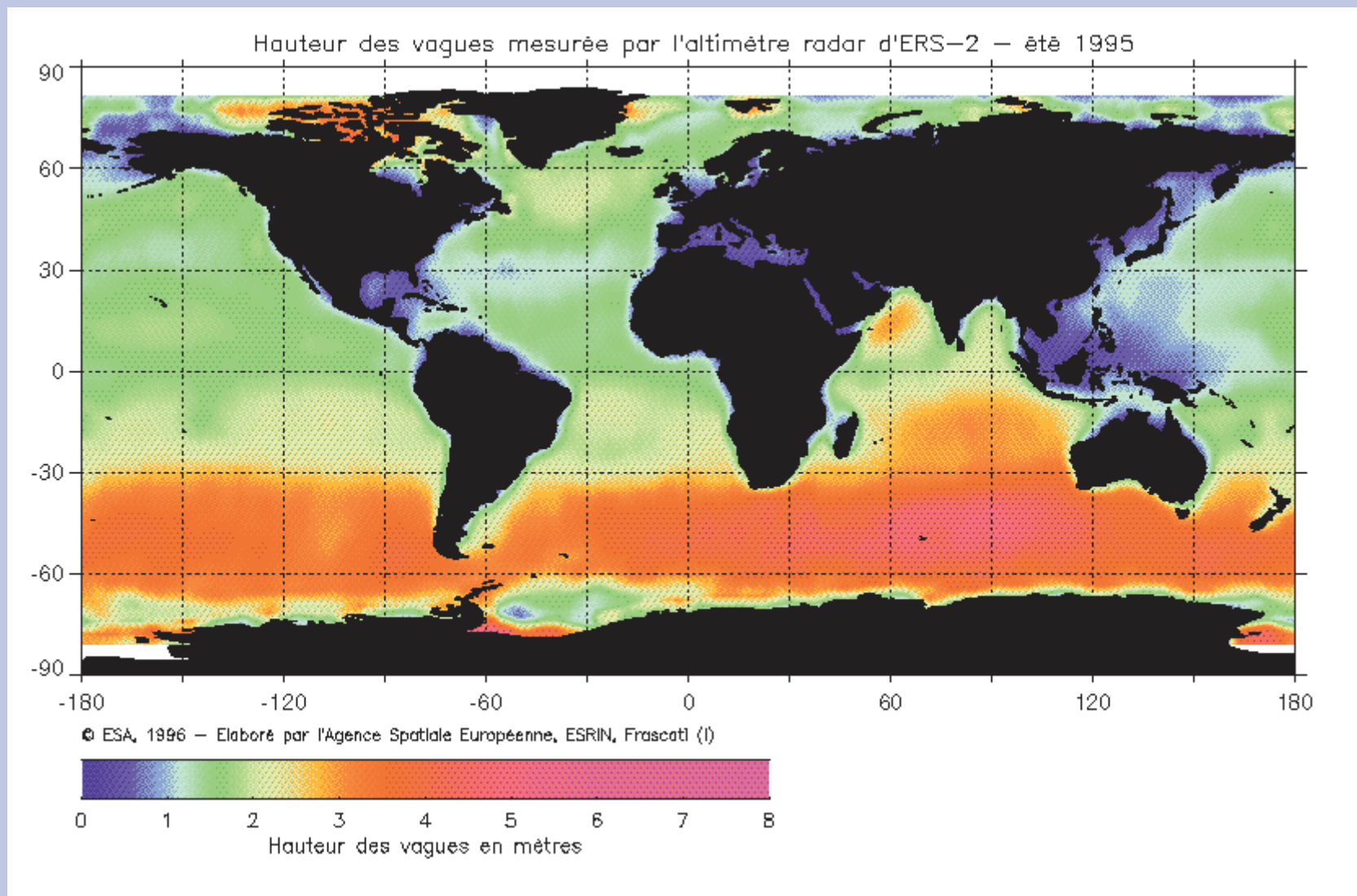
Pola wiatru powierzchniowego

AD 2001.04

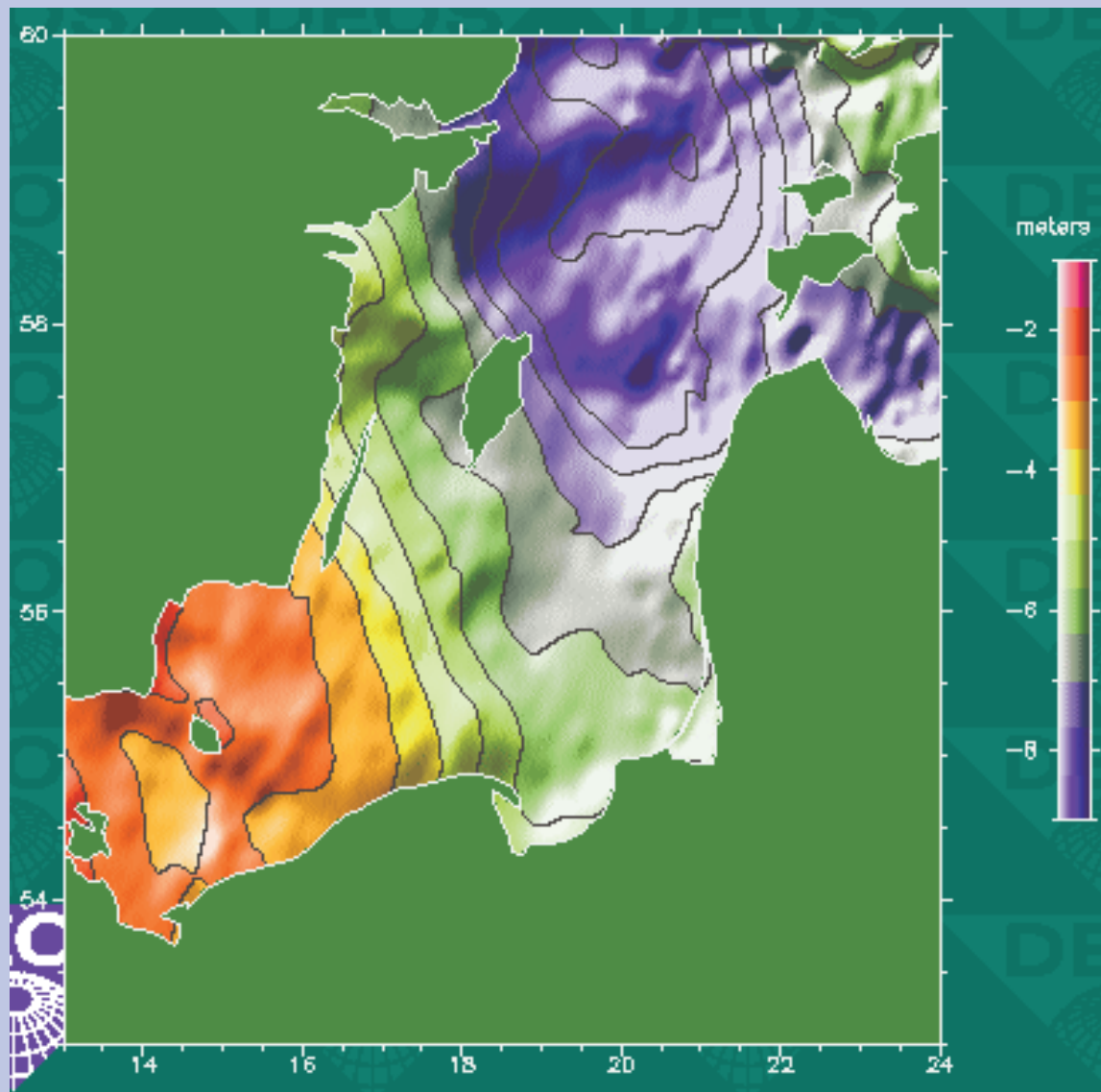


Altimetria

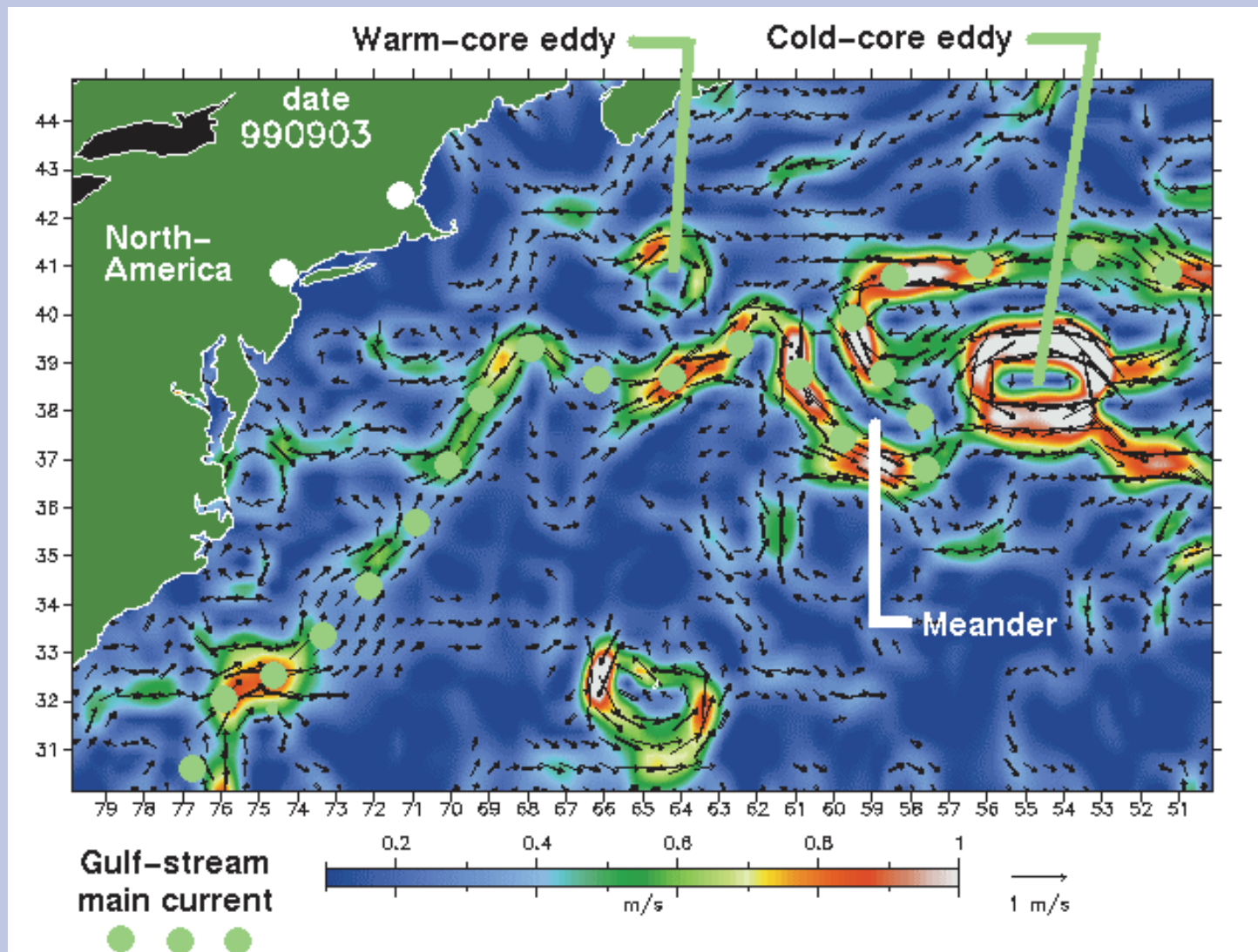




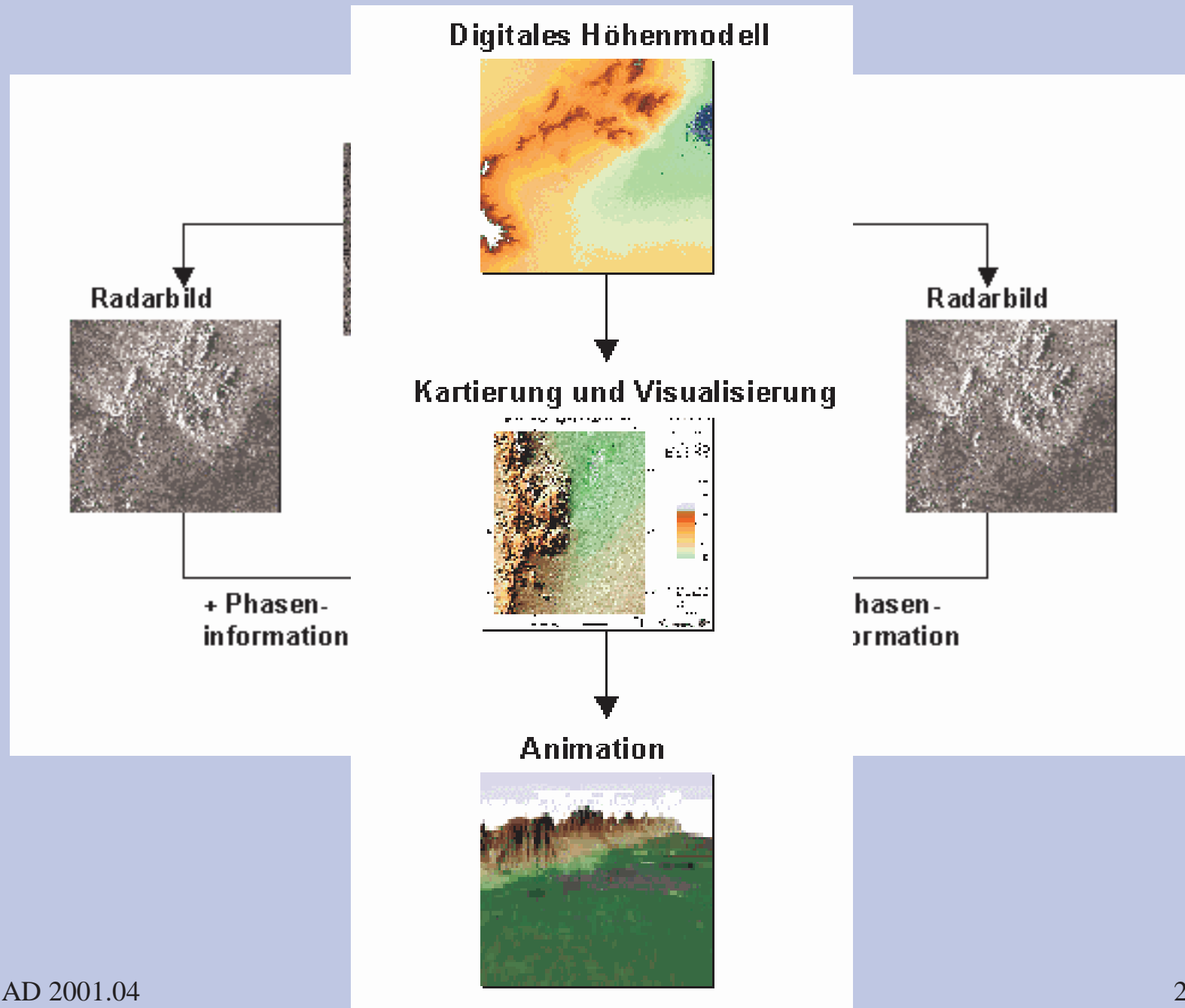
Wysokość fal oceanicznych, lato 1995.



Średni poziom Bałtyku
względem geoidy

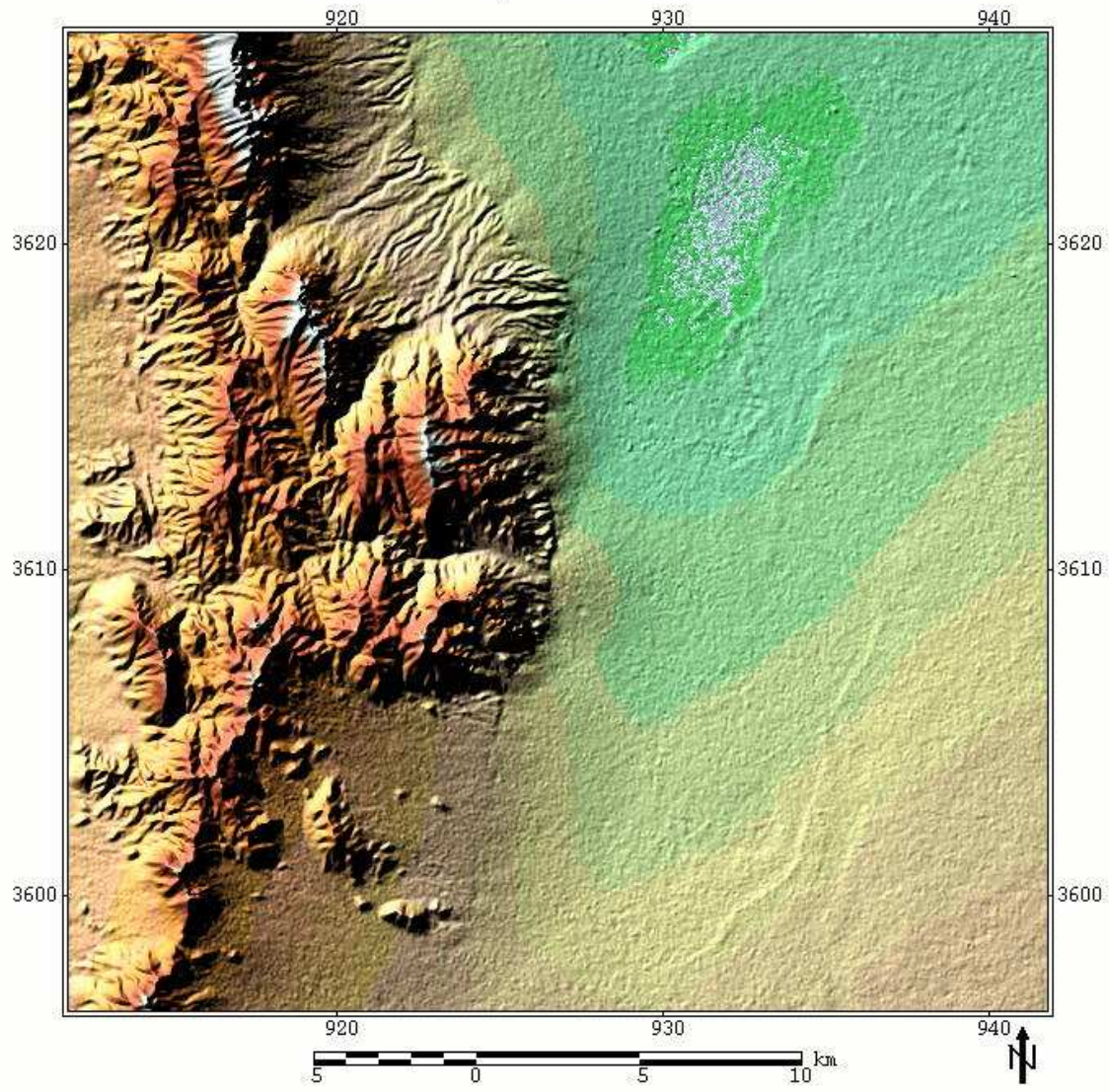


Prądy oceaniczne



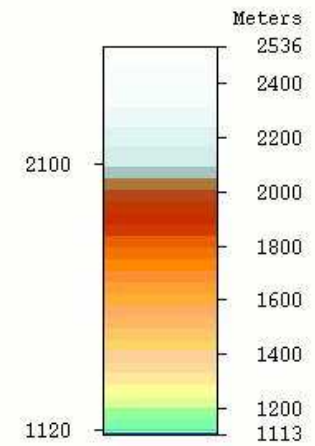
Color Shaded Digital Elevation Model

Sat Feb 12 18:53:04 2000



Site: United States

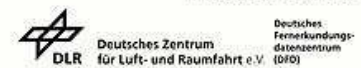
Source: X-SAR SRTM data
Acquis. Date: 12-02-2000
Data take id: 00001 0077
Baseline: 59.2 m /-171.6
Scene Center: 106.7, 32.9

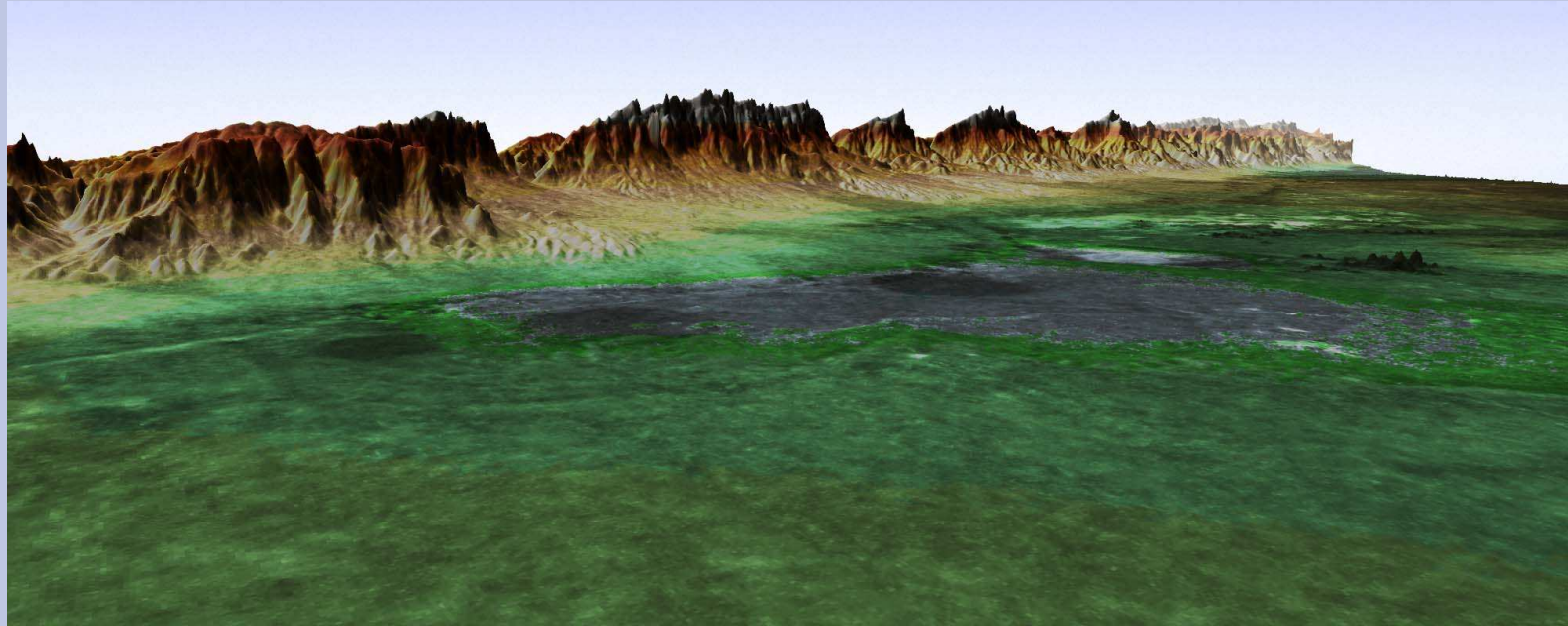


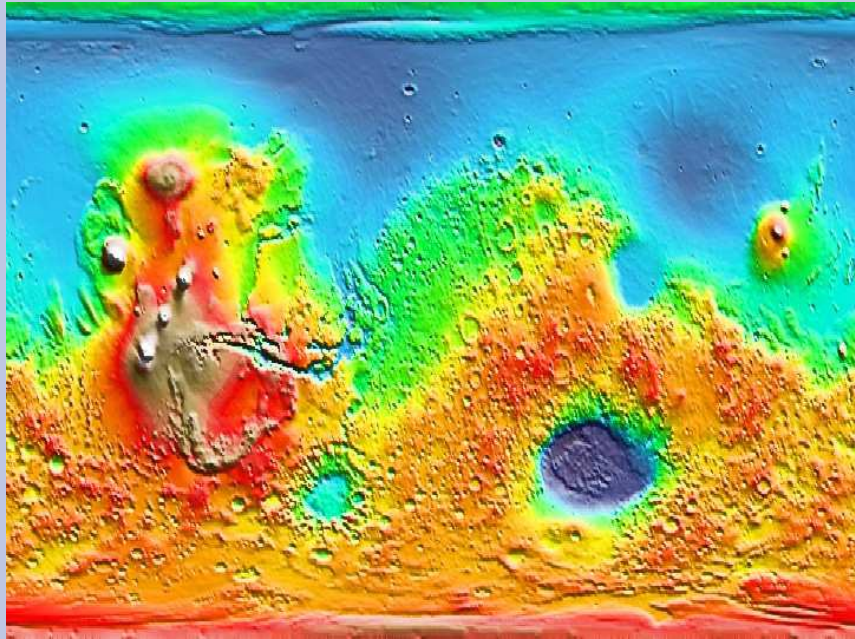
Projection: UTM12 WGS84

	Easting	Northing
Res	50.0	50.0 m
NW	911800.0	3626450.0 m
SE	941800.0	3596450.0 m

Produced by DLR

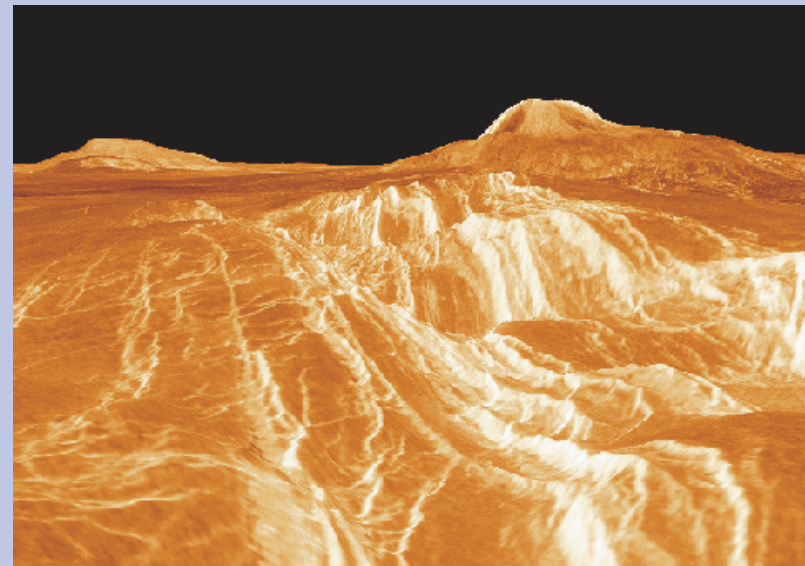






Powierzchnia Marsa

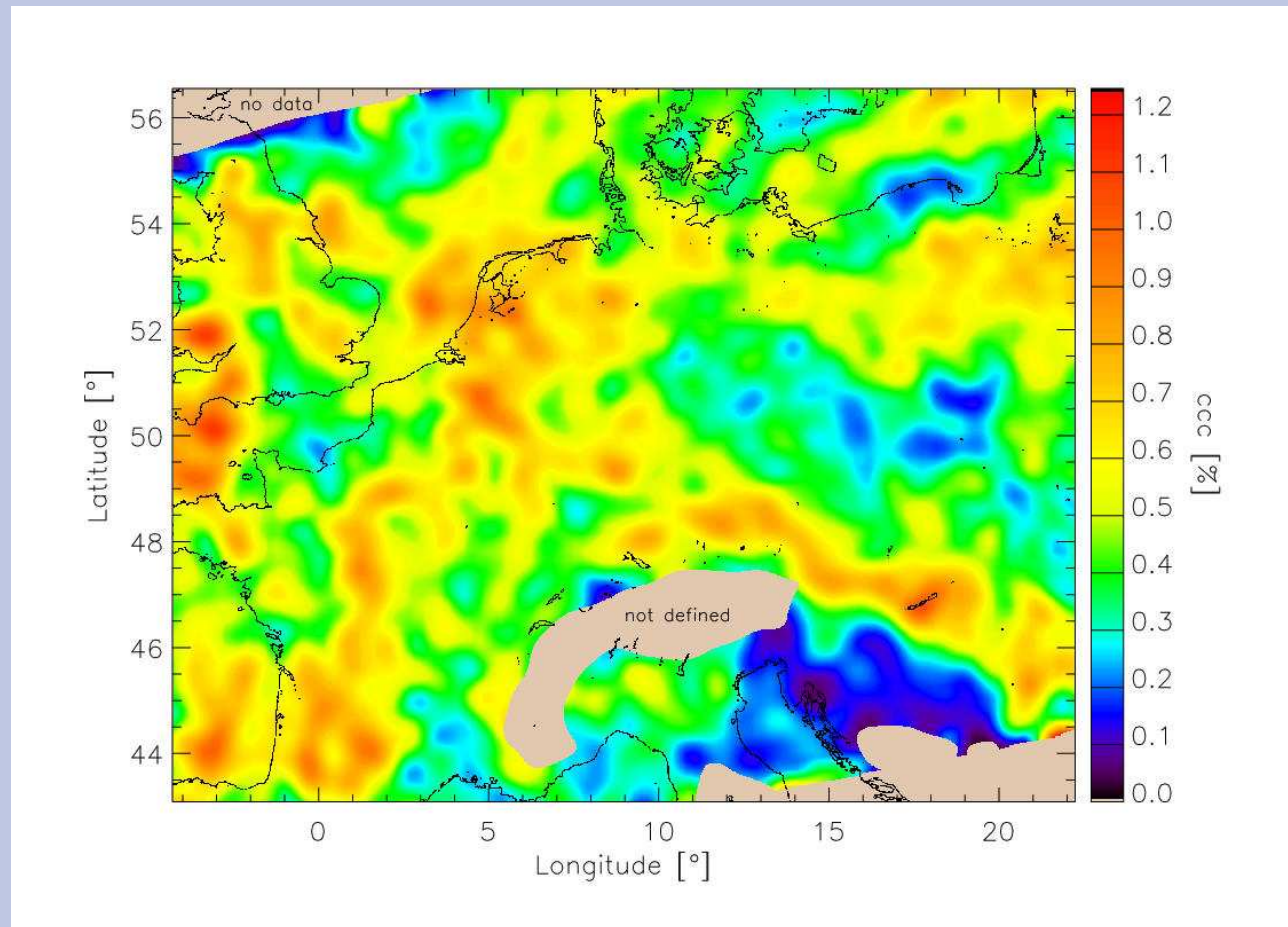
Powierzchnia Wenus



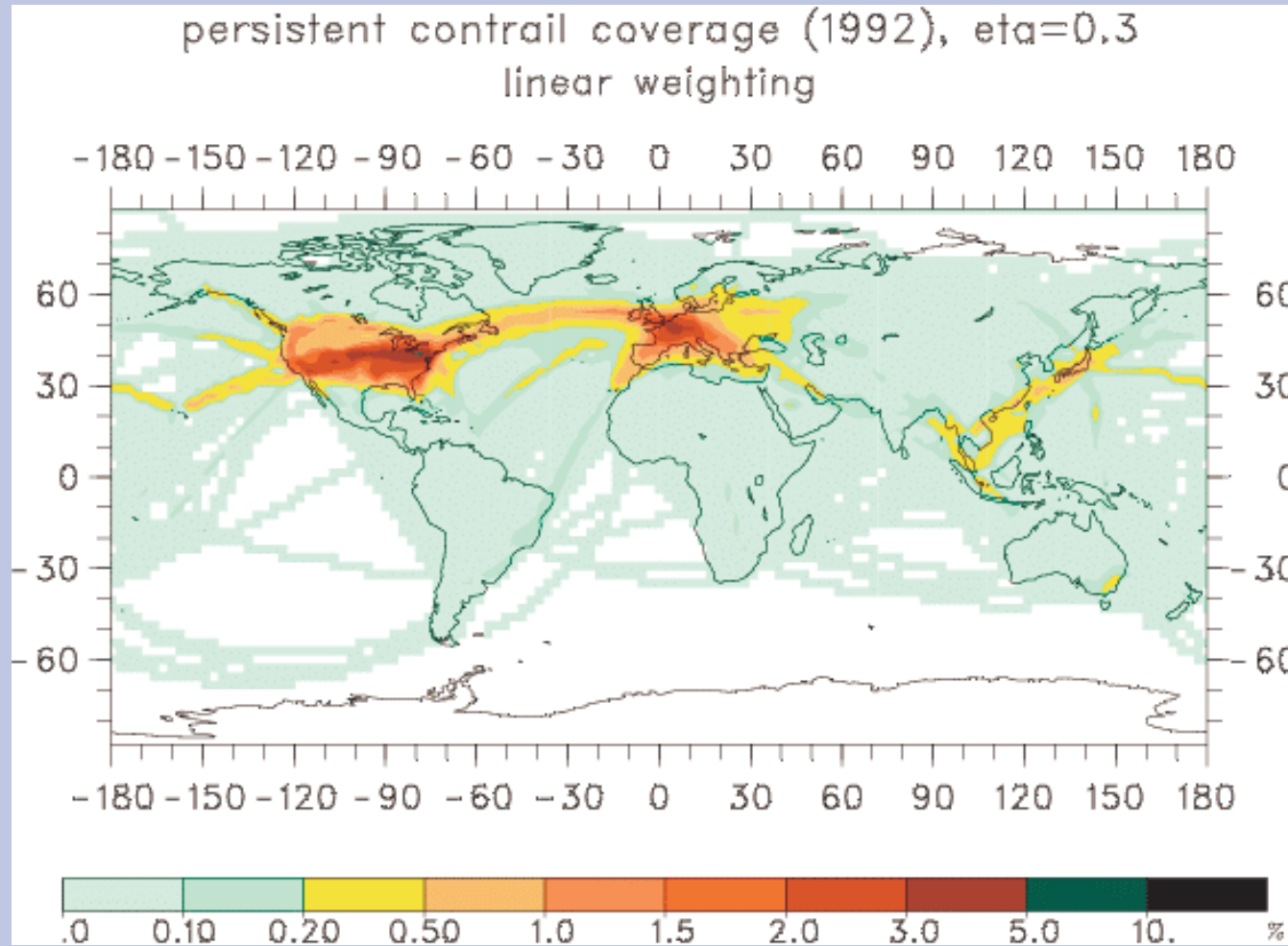
Contrails over central Europe on 4th May 1995 at 7:43 UTC
based on NOAA12 AVHRR satellite data (Mannstein et al., 1997).



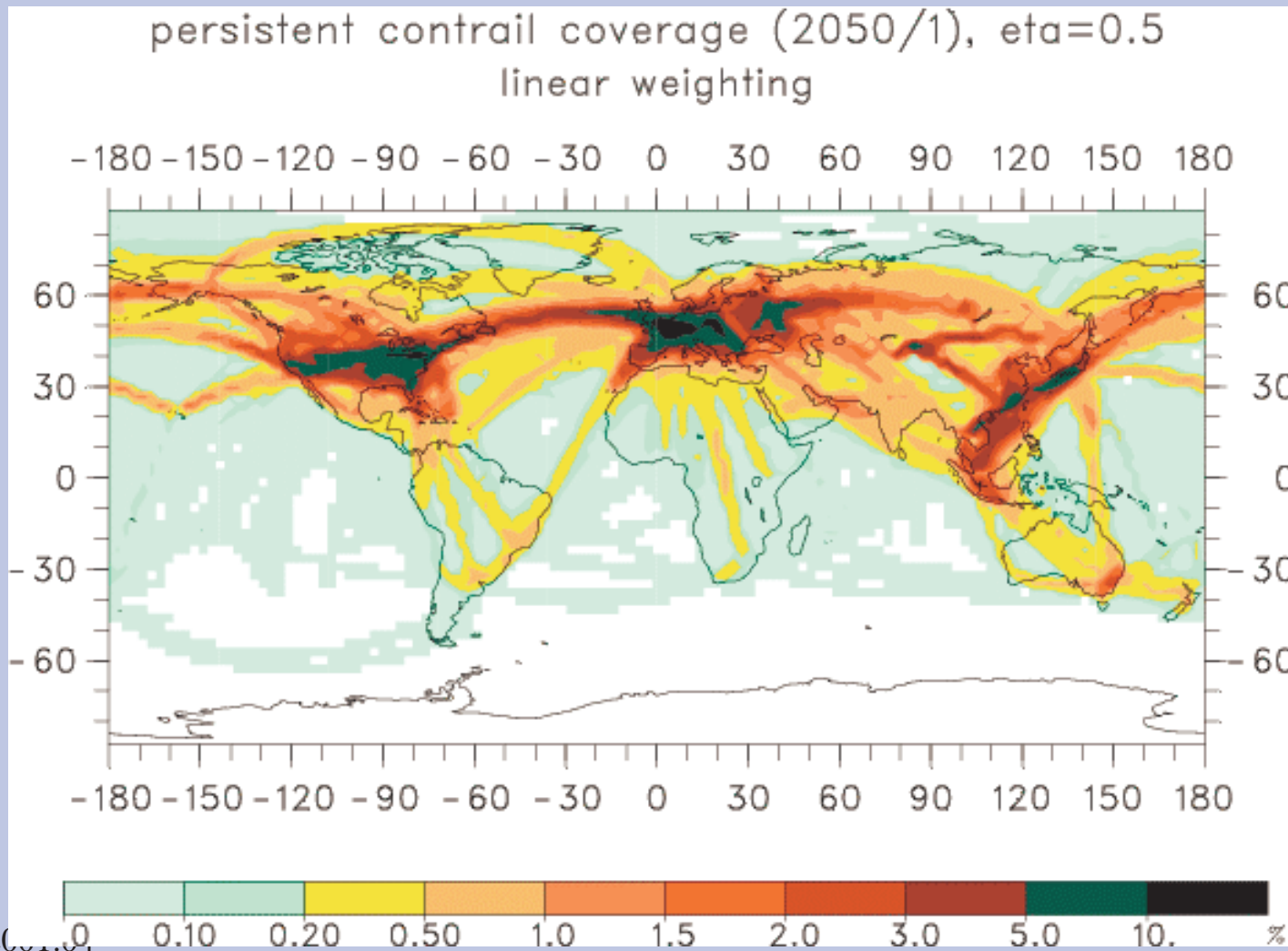
Annual mean contrail coverage at noon over mid Europe in 1996 as determined from NOAA-14 satellite data (Mannstein et al., 1997).



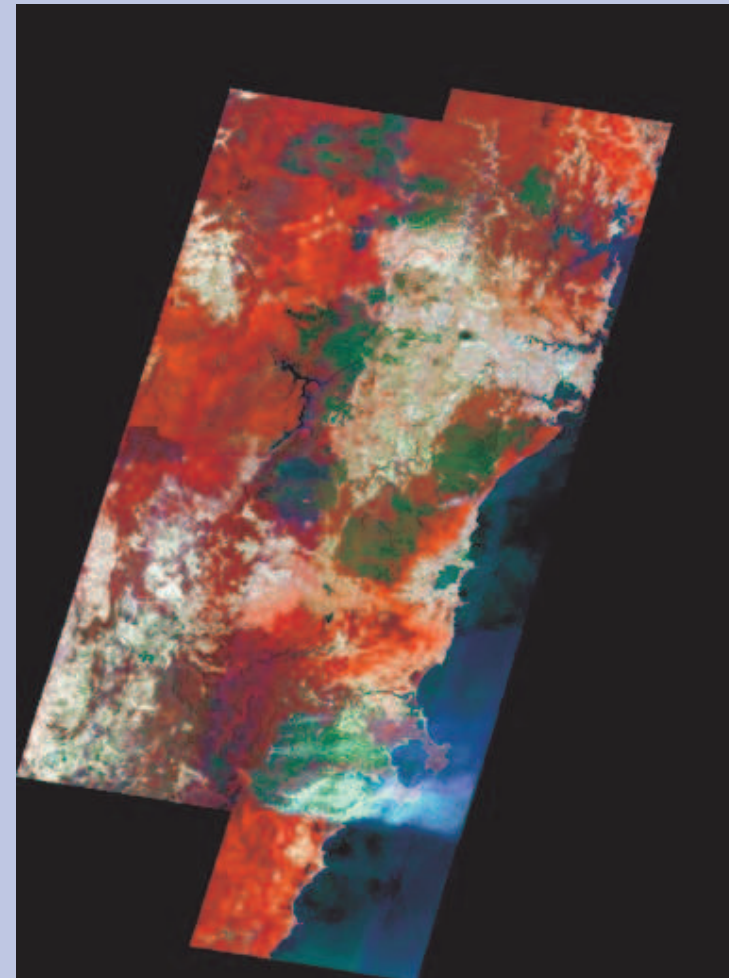
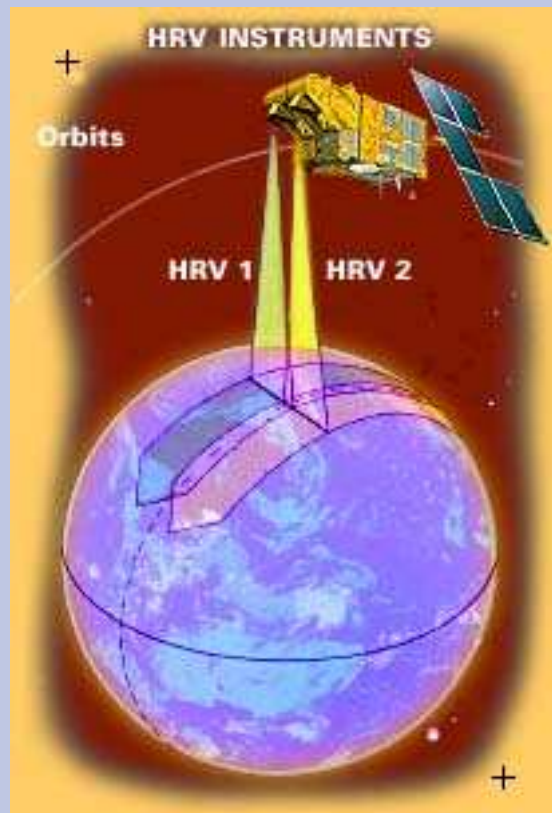
Persistent contrail coverage (in % area cover) for the globe for the 1992 aviation fleet, assuming a linear dependence on fuel consumption and an overall efficiency of propulsion η of 0.3. The global mean cover is 0.1%. (From Sausen et al., 1998.)



Persistent contrail coverage (in % area cover) based on meteorological analysis data and on the fuel emission database for 2050 (IS92 fuel consumption scenario for 2050) assuming a linear dependence on fuel consumption and an overall efficiency of propulsion η of 0.5; global mean cover is 0.5%. Compare with Figure 3.4.5. (From Gierens et al., 1998.)



Skaning powierzchni Ziemi



Pożar buszu w Australii



Monitorowanie wyrębu lasu

ERS-1



Envisat



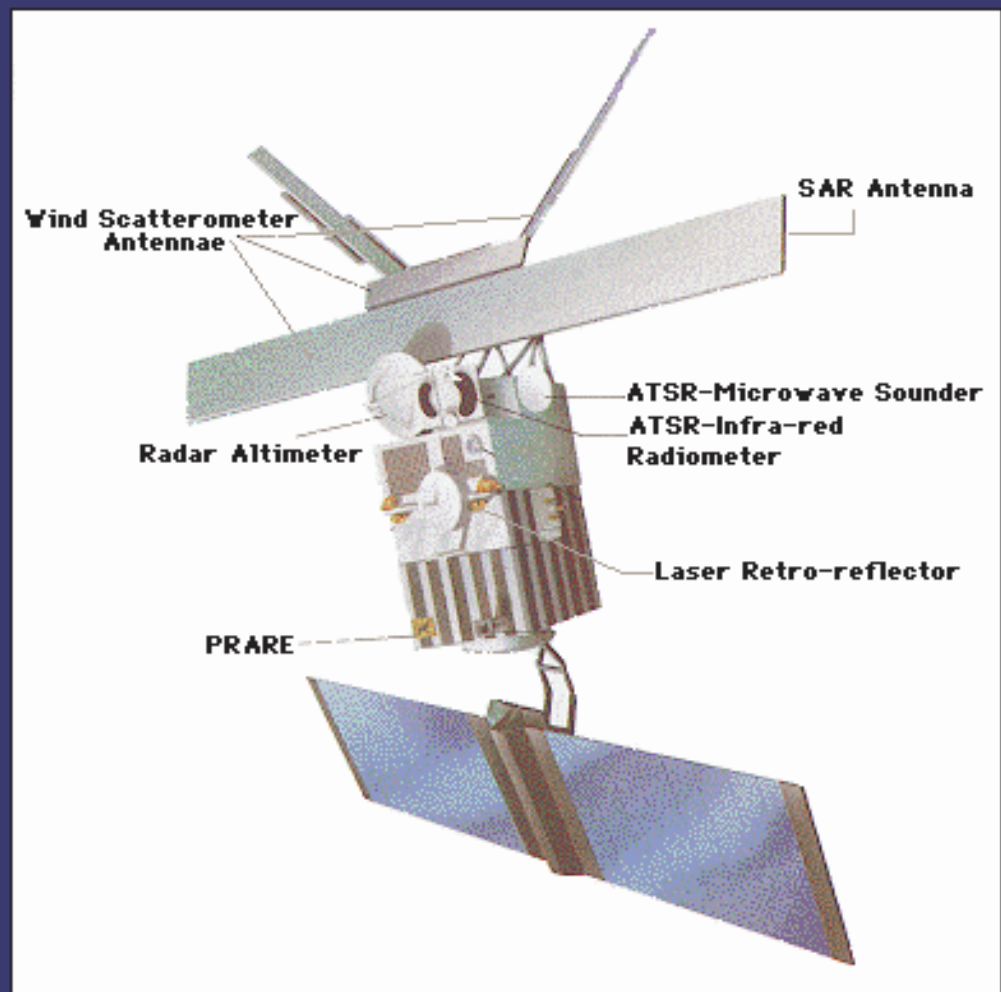
Topexposeidon



AD 2001.04



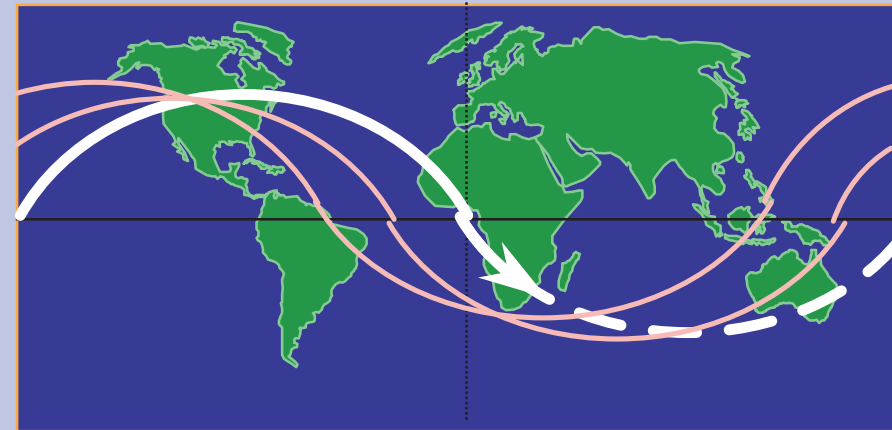
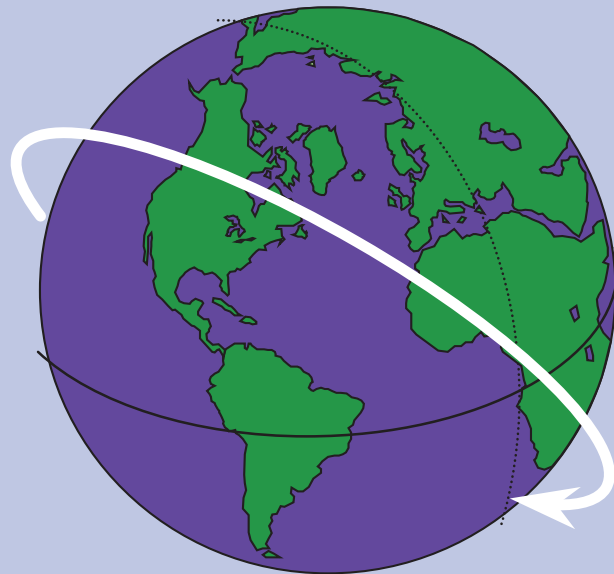
ERS-1



ERS-1 Payload

Orbity SSZ

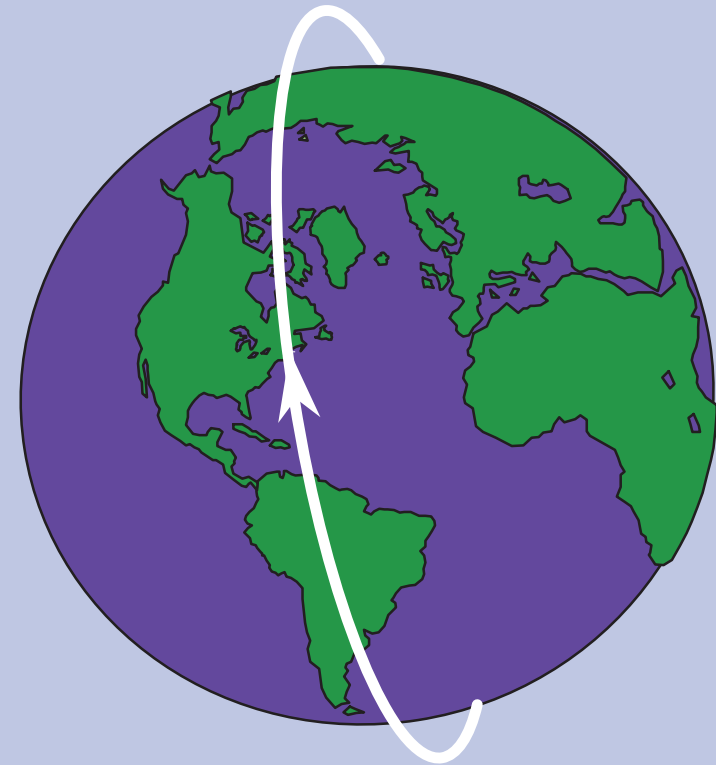
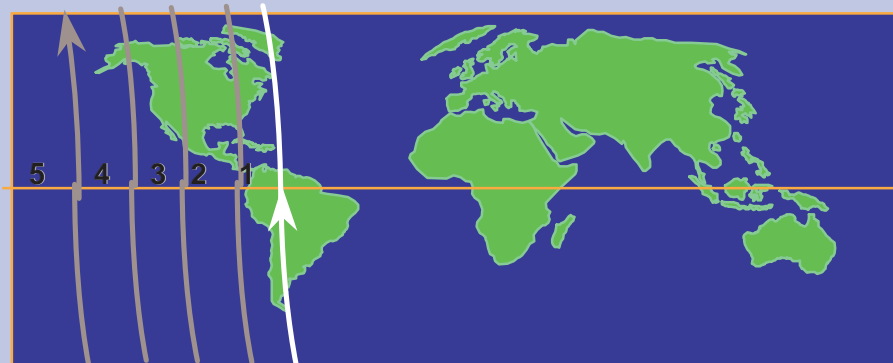
Typowa orbita SSZ dryfuje w kierunku zachodnim o 22 stopnie/obieg

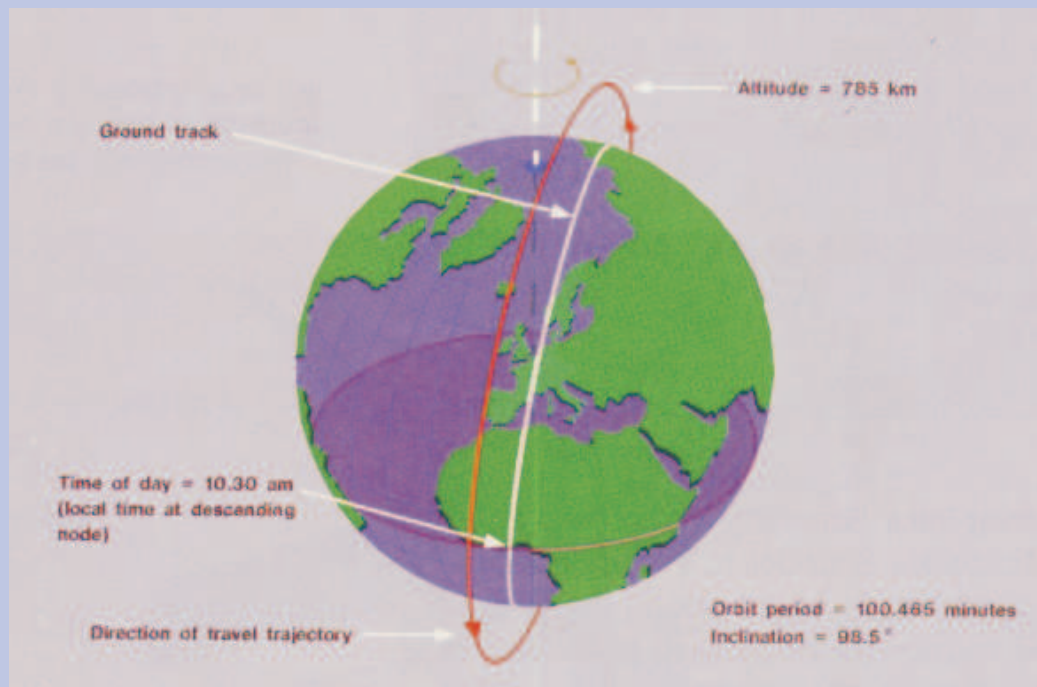


Orbity synchroniczne ze Słonecznikiem

- Orbity q-polarne

Widok łożdu na powierzchni ziemi



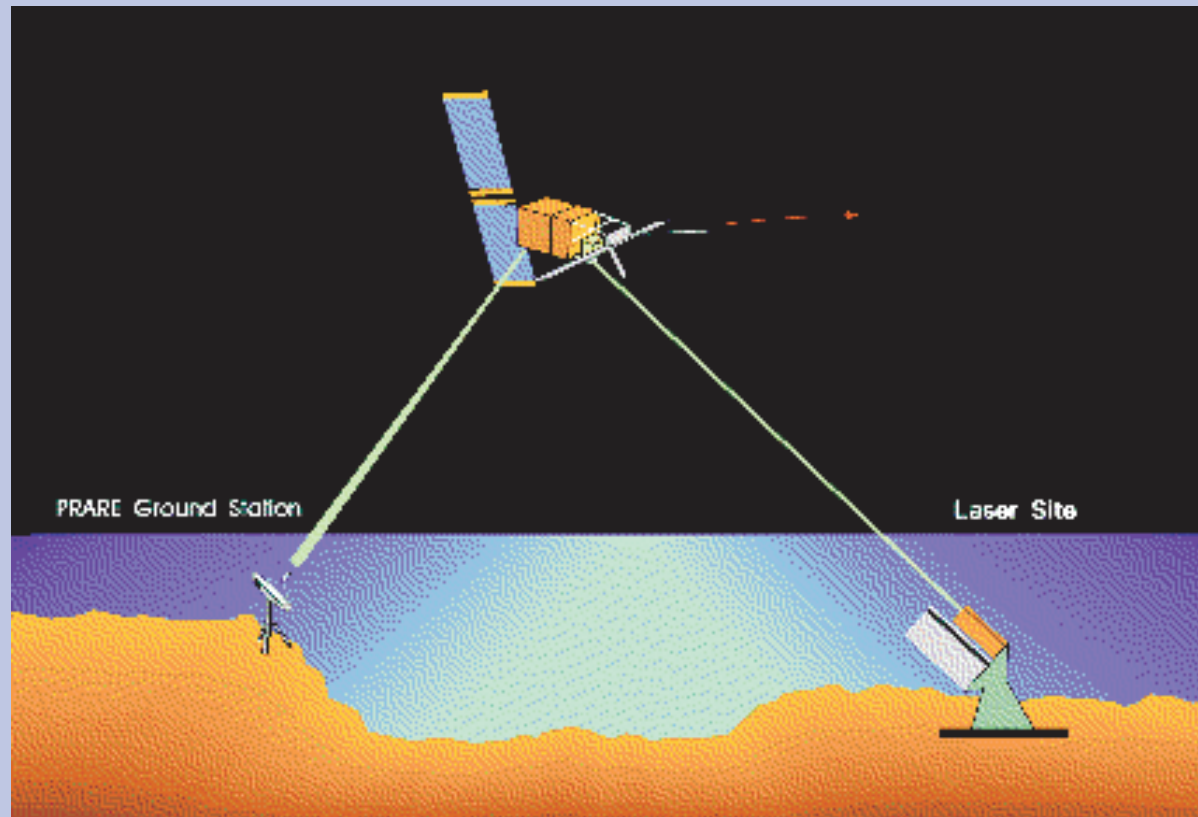


Orbita quasi-polarna
synchroniczna ze Słońcem

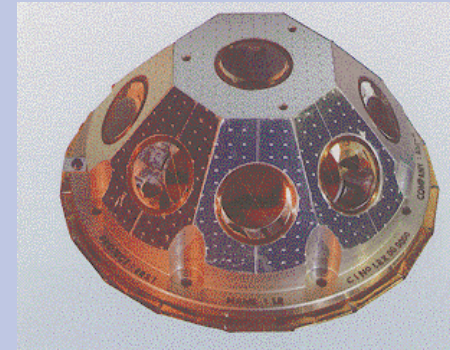
Pokrycie powierzchni pomiarami
SAR i altimetrycznymi
(cykl 3-dniowy)



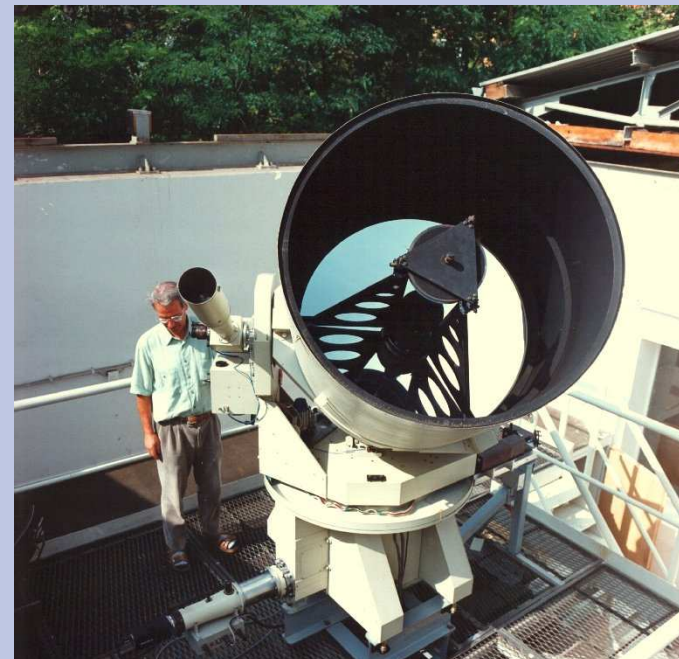
Obserwacja SSZ: wyznaczenie odległości i szybkości radialnej



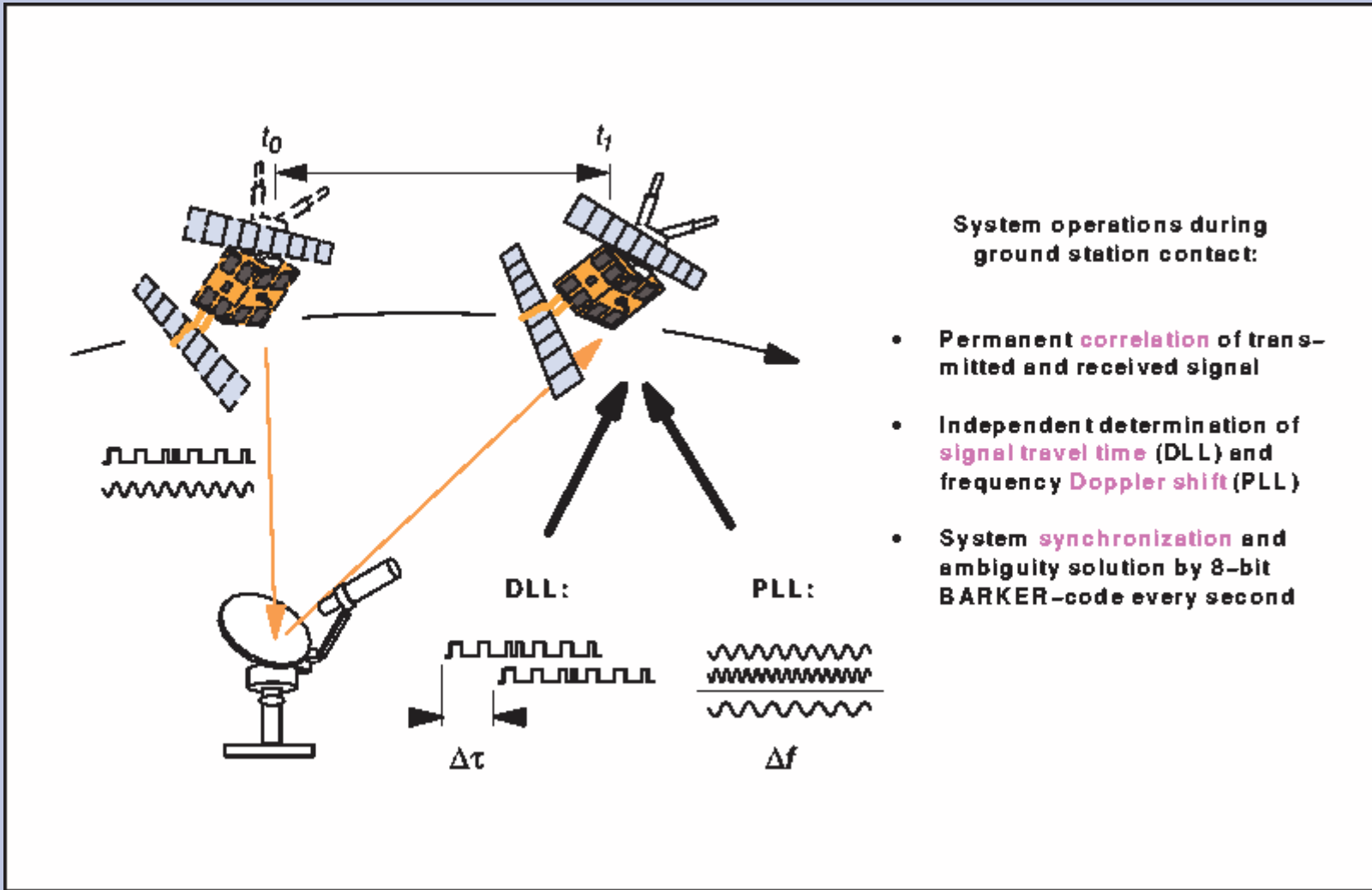
Odbłyśnik laserowy

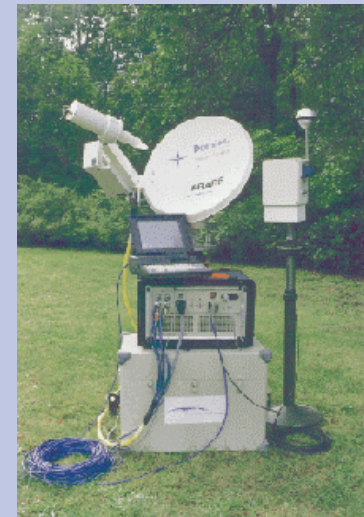
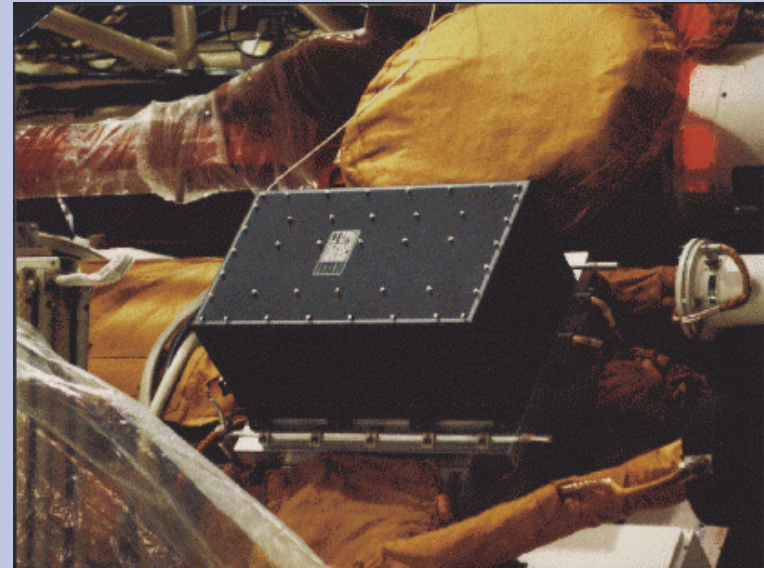


Dalmierz laserowy

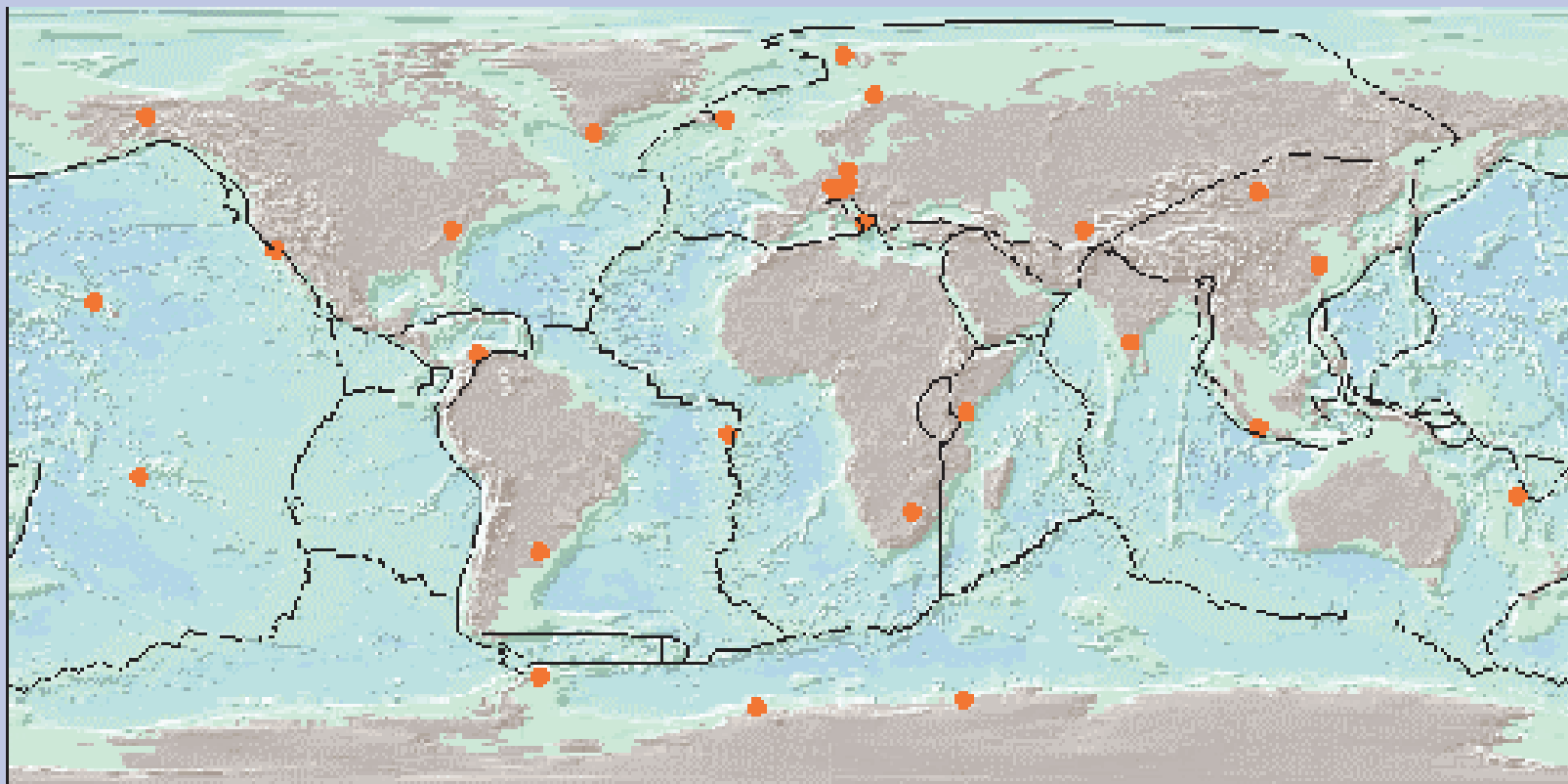


AD 2001.04



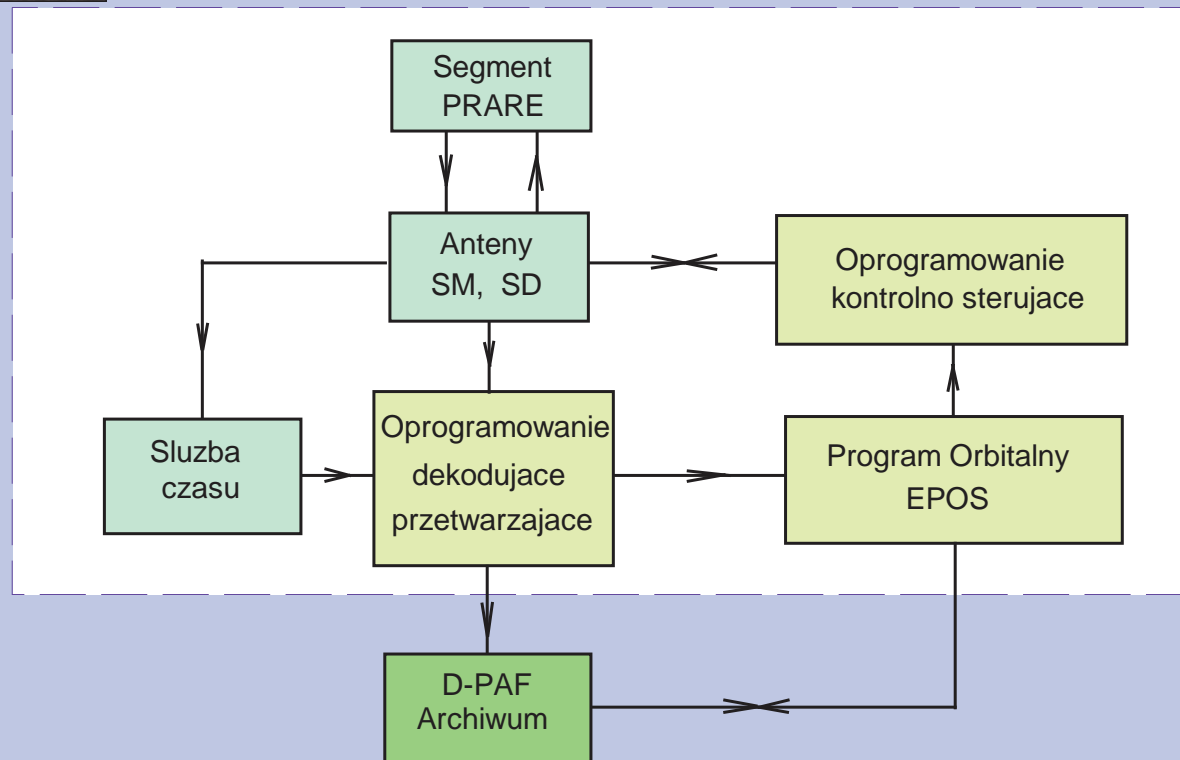


Sieć stacji - anten PRARE





PRARE stacja master w DLR Oberpfaffenhofen



Centrum kontroli misji w Darmstadt



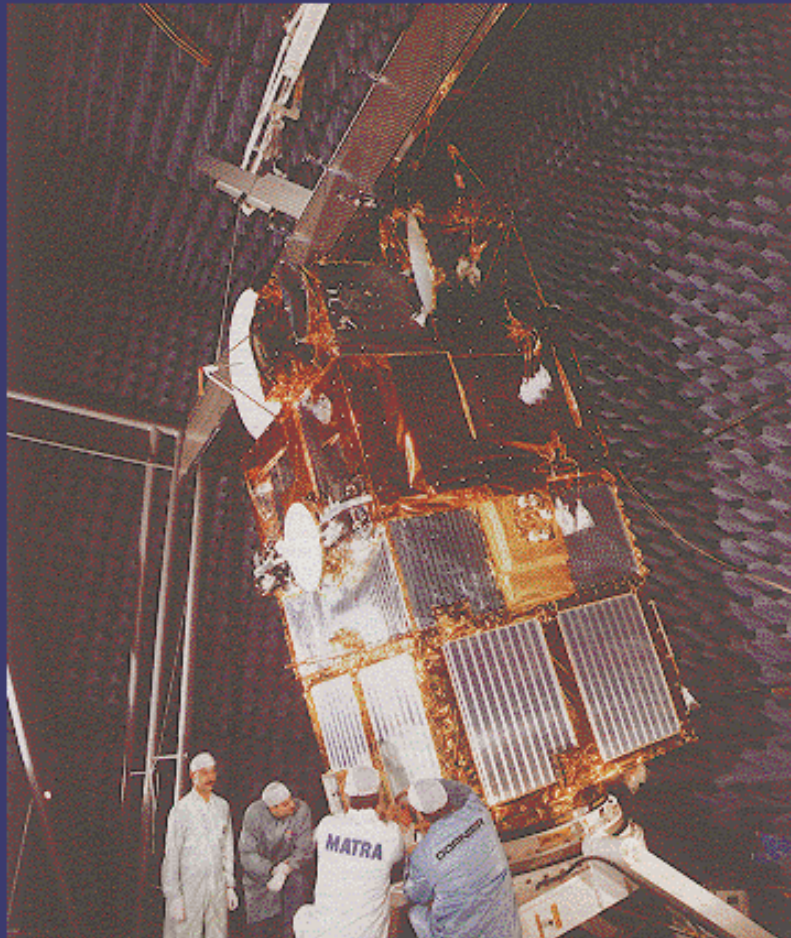
AD 2001.04

Antena w Fucino



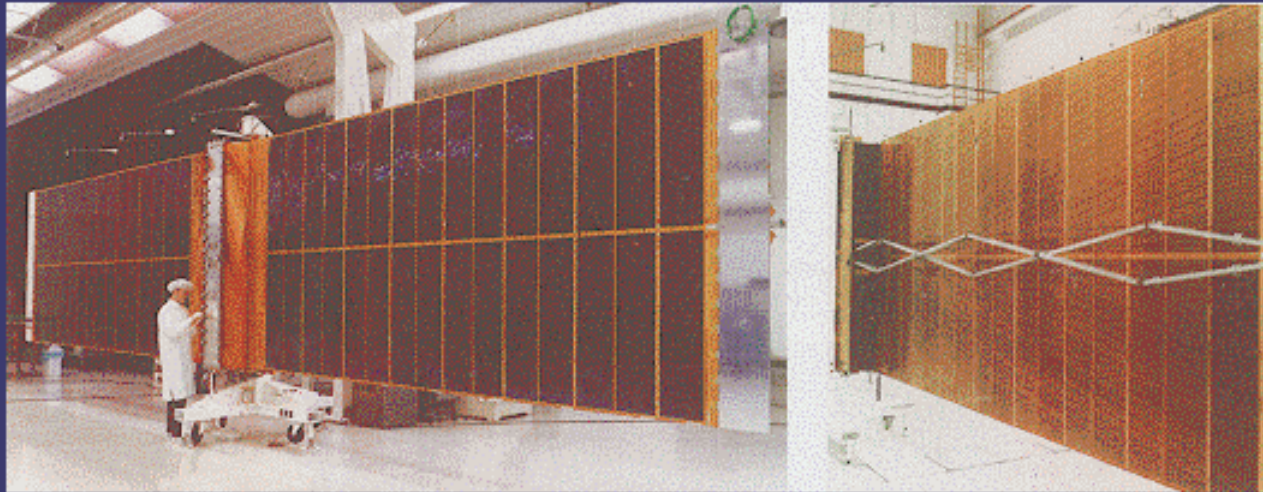
41

ERS-1 inside the Interspace Test Facility



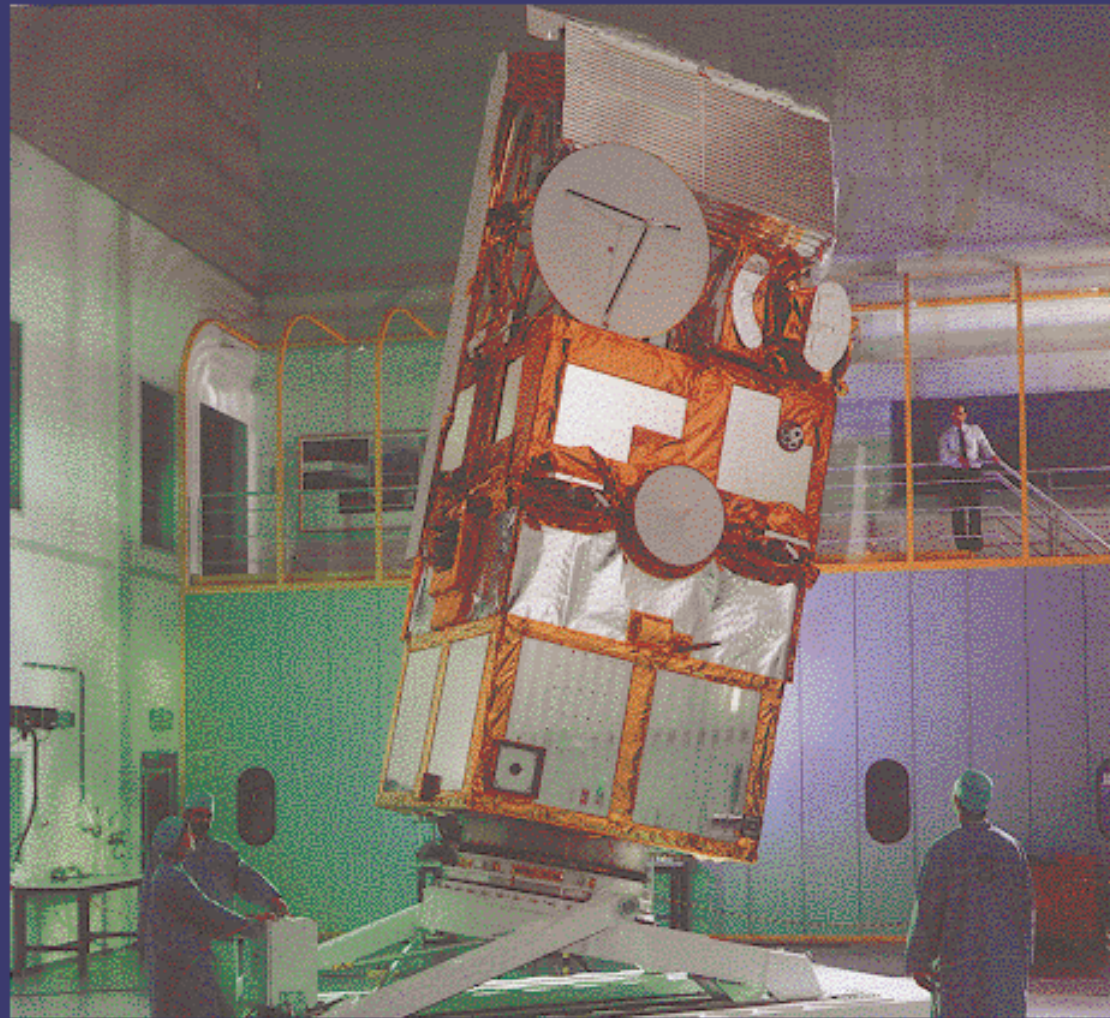
ERS-1 fully deployed inside the Interspace Test facility, Toulouse, France.

ERS-1 Solar Array



Front and rear side of ERS-1 solar array. The rear view shows the pantograph deployment mechanism.

ERS-1 Spacecraft in Launch Configuration

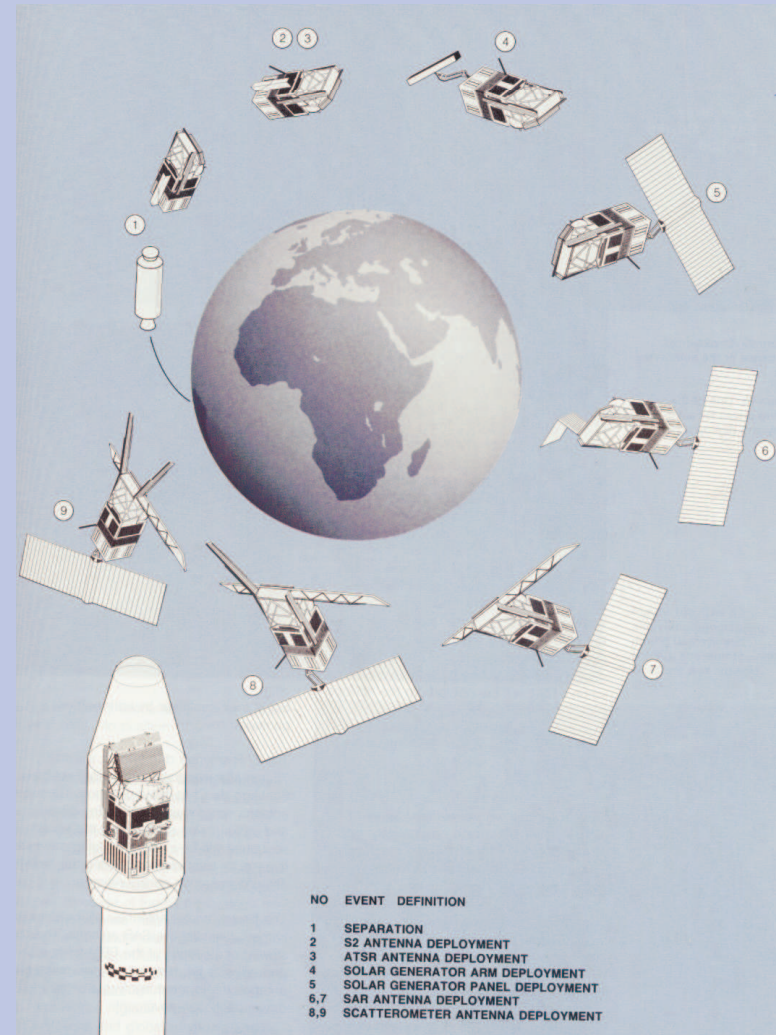


ERS-1 spacecraft in launch configuration, the arrays and antennae folded, during tests at ESA's ESTEC facilities in Noordwijk, The Netherlands.

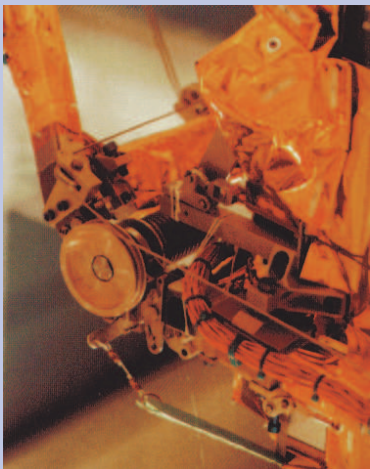
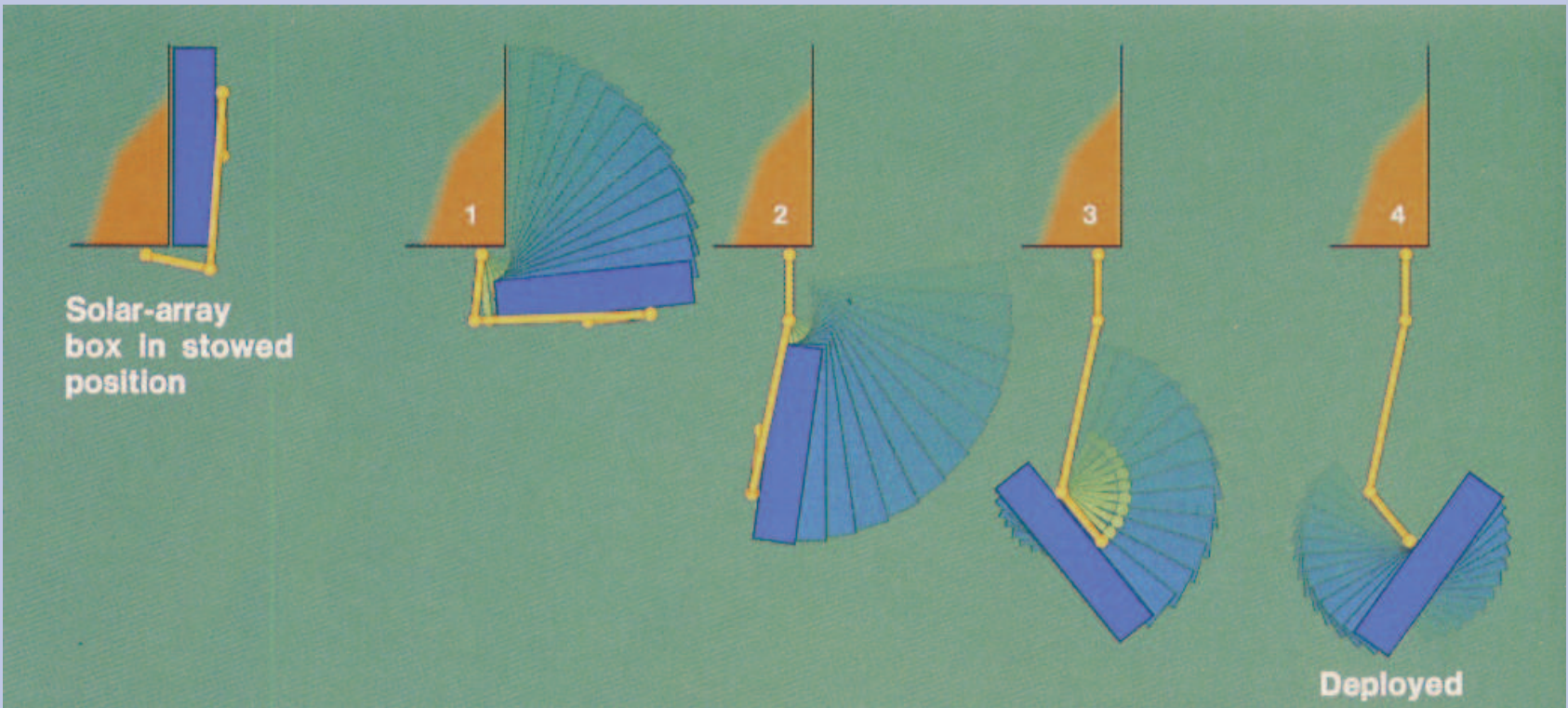
Początek misji ERS-1, ERS-2



AD 2001.04

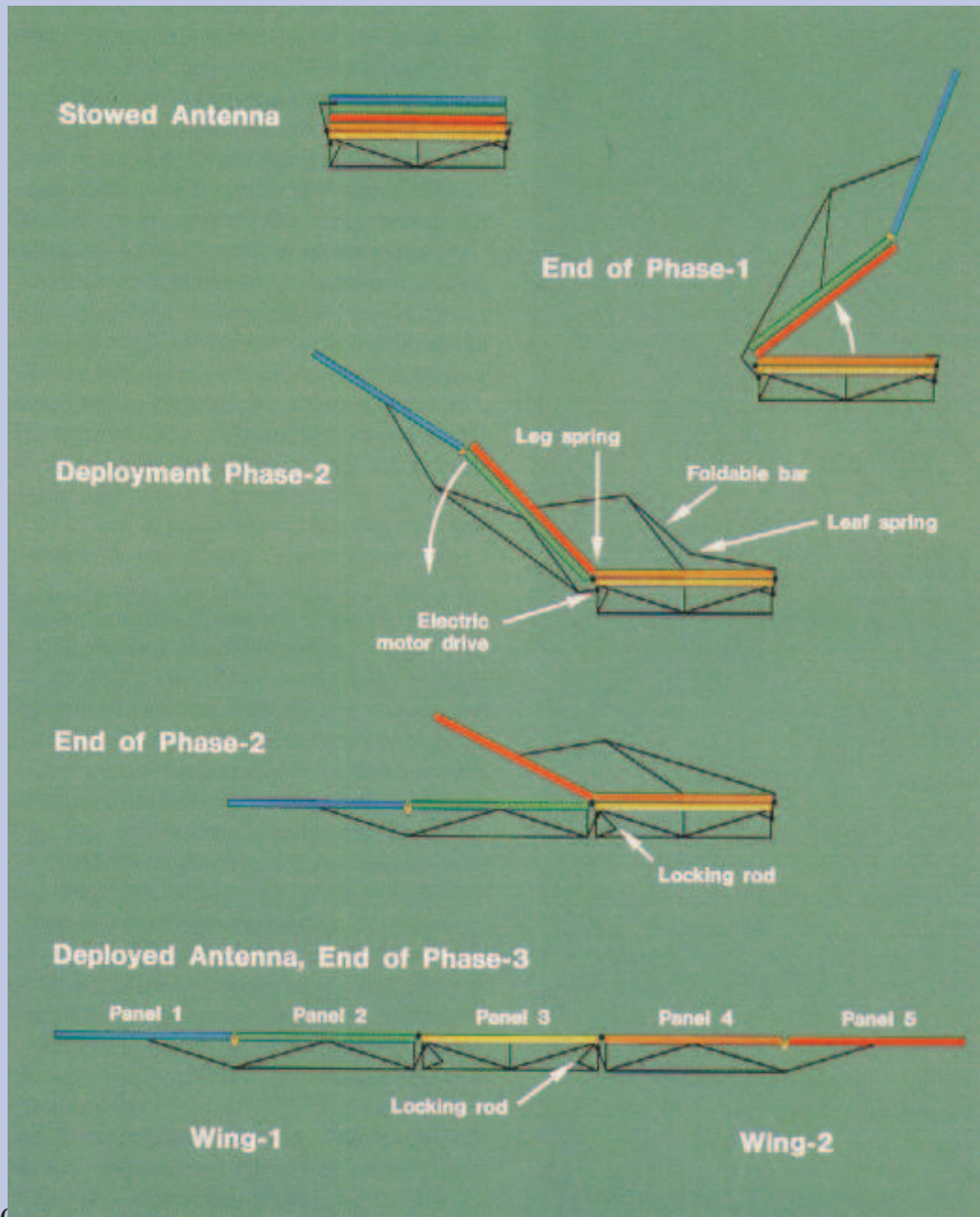


45



AD 2001.04

Otwieranie baterii słonecznych



Rozpakowanie
anteny SAR

Centrum kontroli misji w Darmstadt

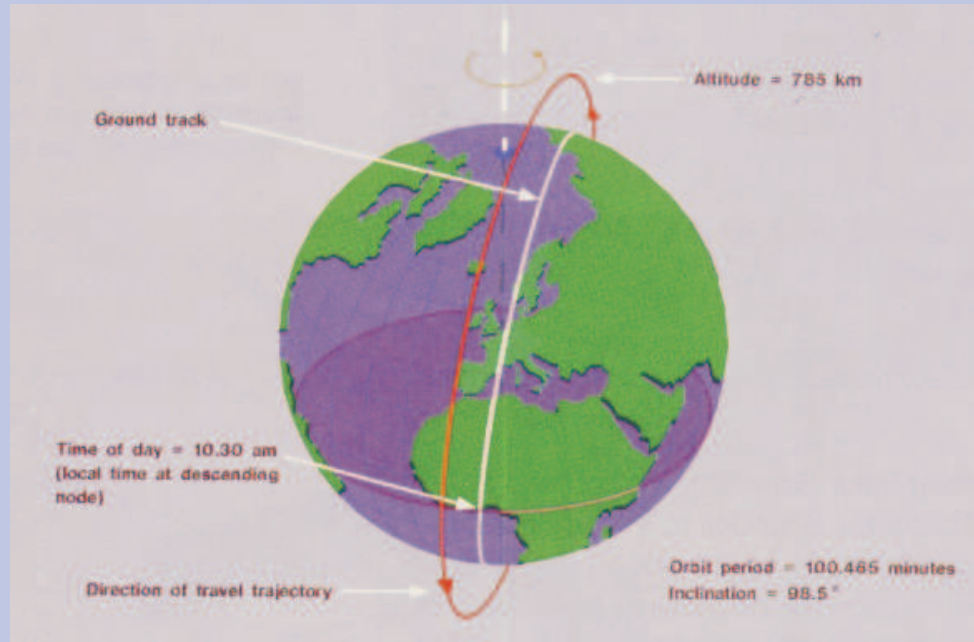


AD 2001.04

Antena w Fucino

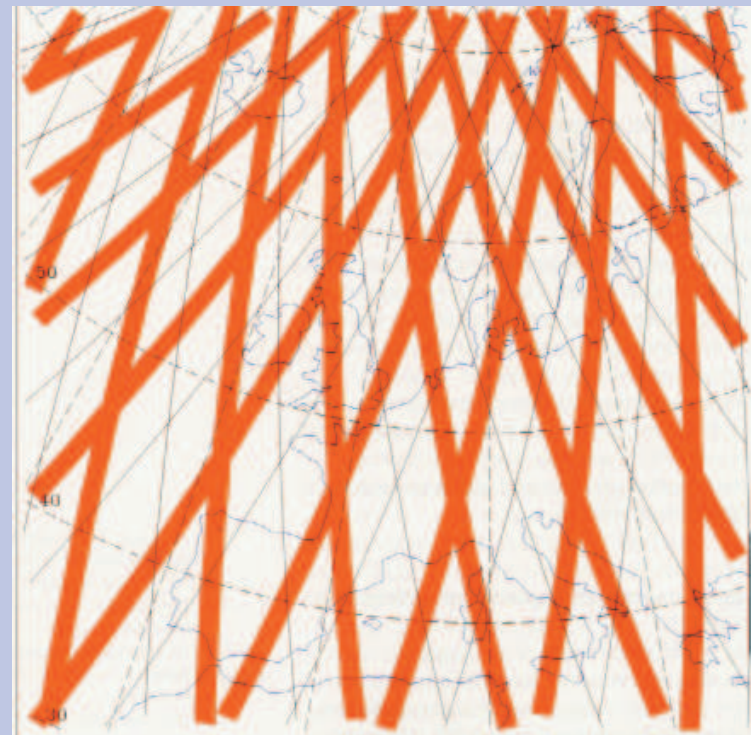


48

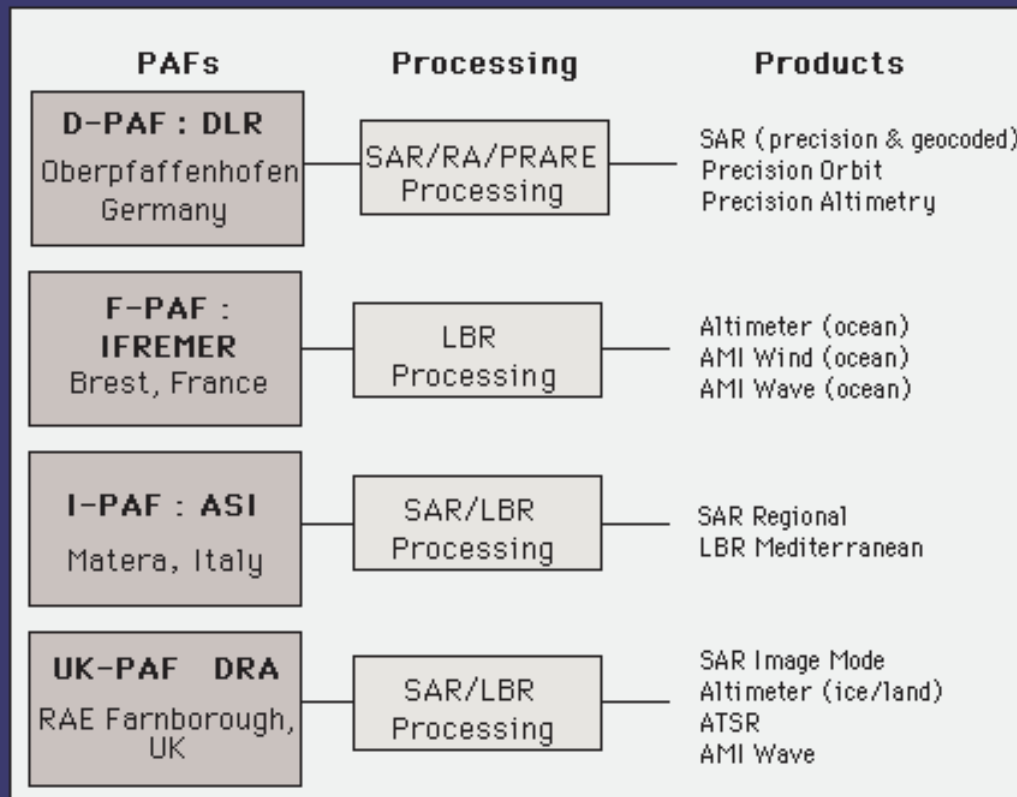


Orbita quasi-polarna
synchroniczna ze Słońcem

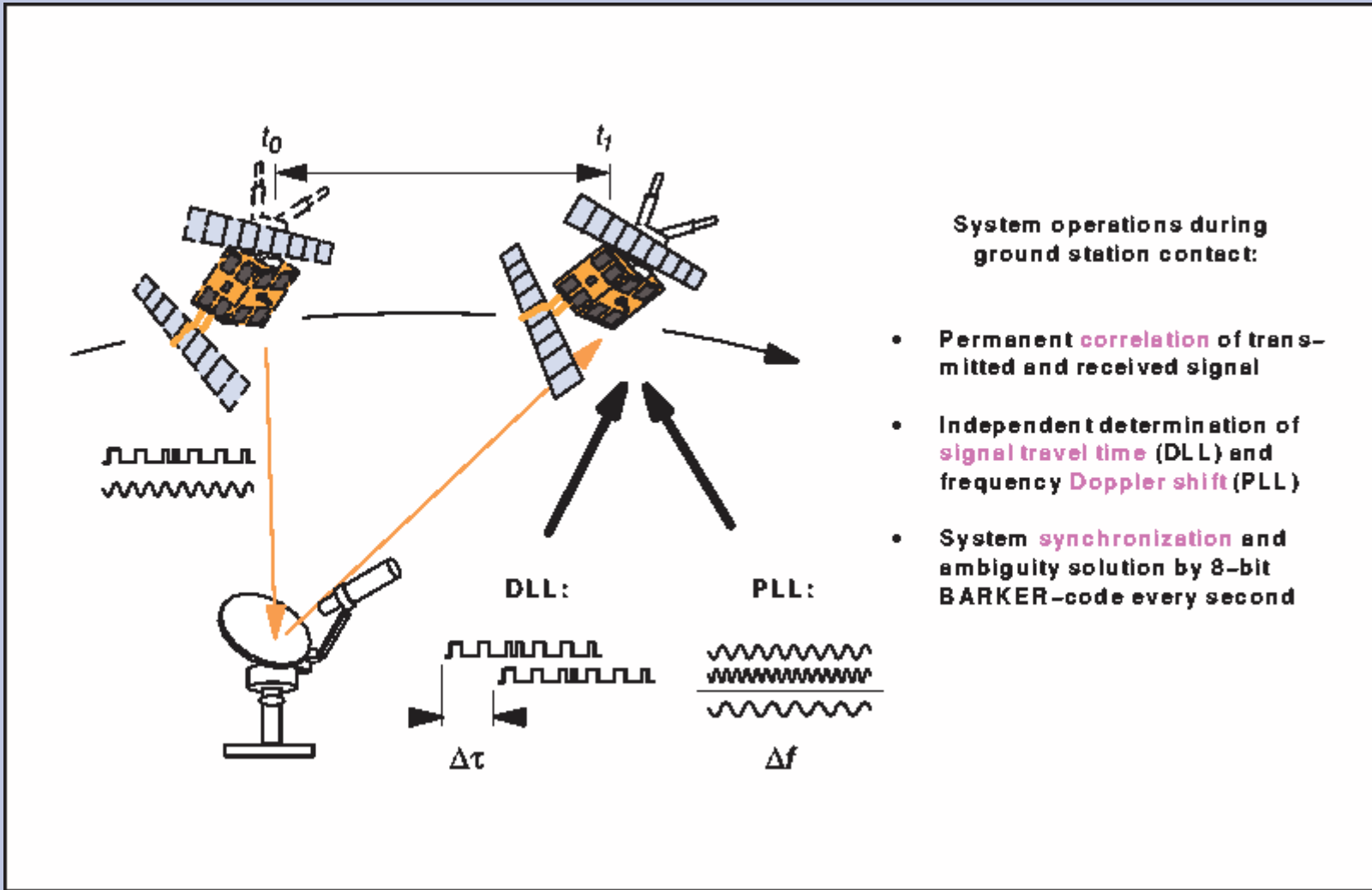
Pokrycie powierzchni pomiarami
SAR i altimetrycznymi
(cykl 3-dniowy)

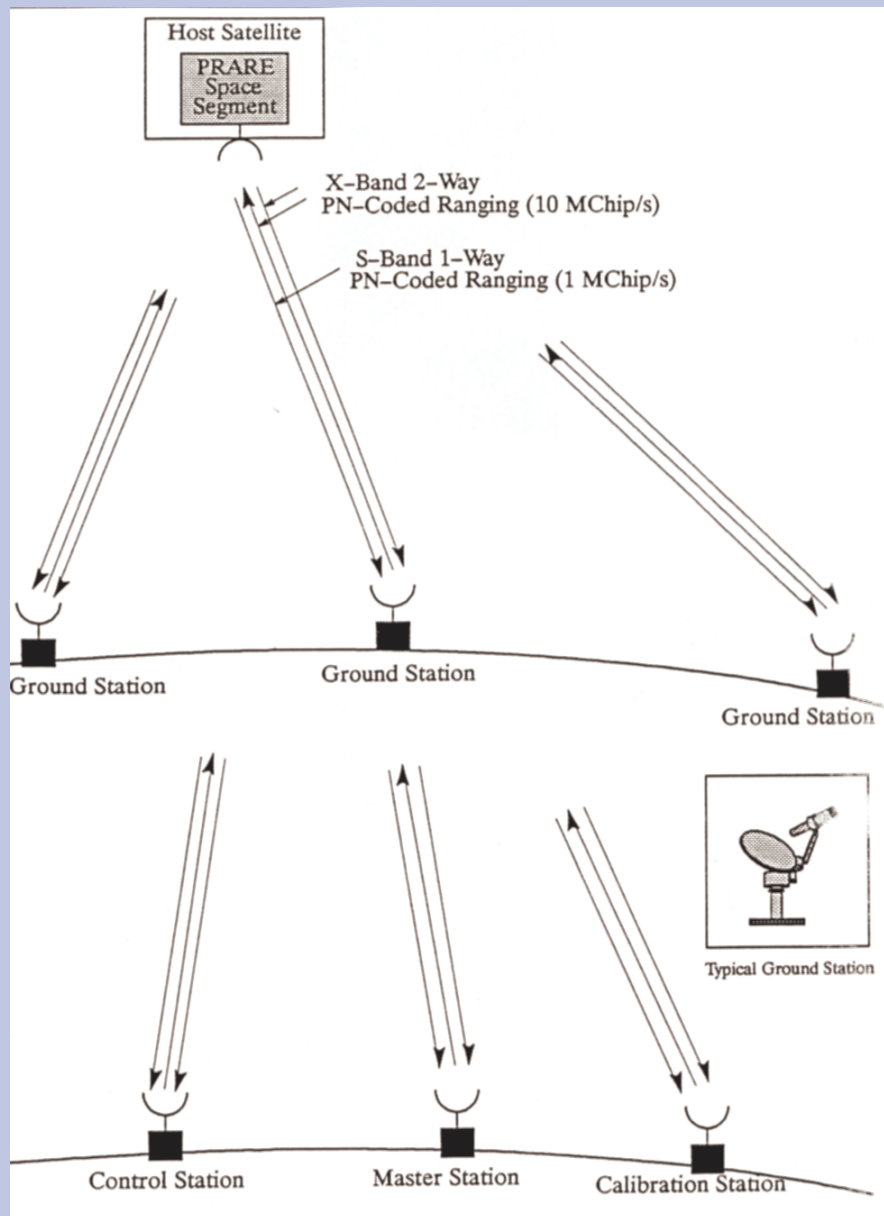


PAF Responsibilities



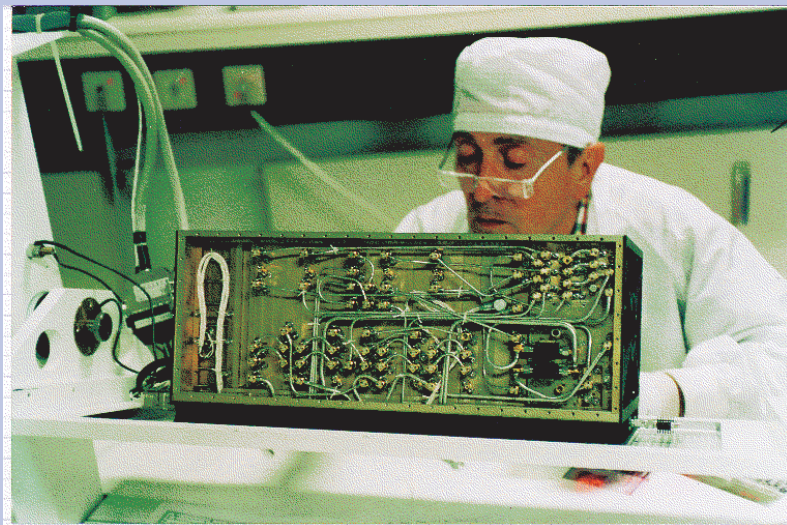
Harmonised responsibilities of the Processing and Archiving Facilities.





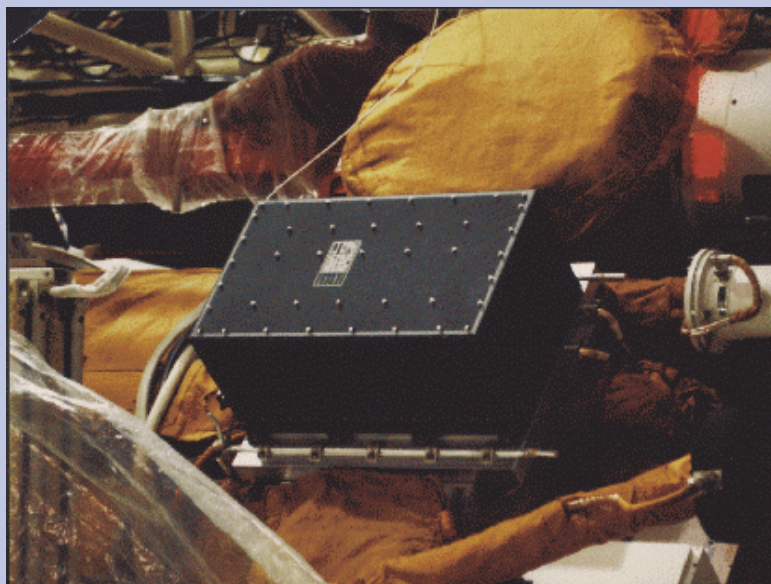
System PRARE

- dwupasmowy (S, X),
- dwugałęziowy,
- możliwość dwustronnej,
- transmisji danych,
- własna telemetria elektroniki,
- własny system czasu.

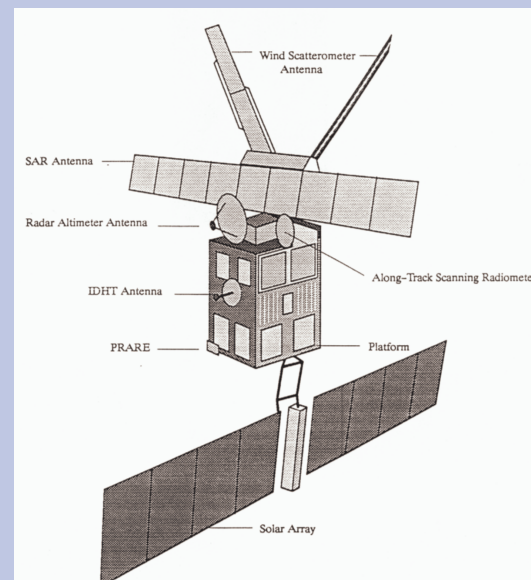


Segment pokładowy

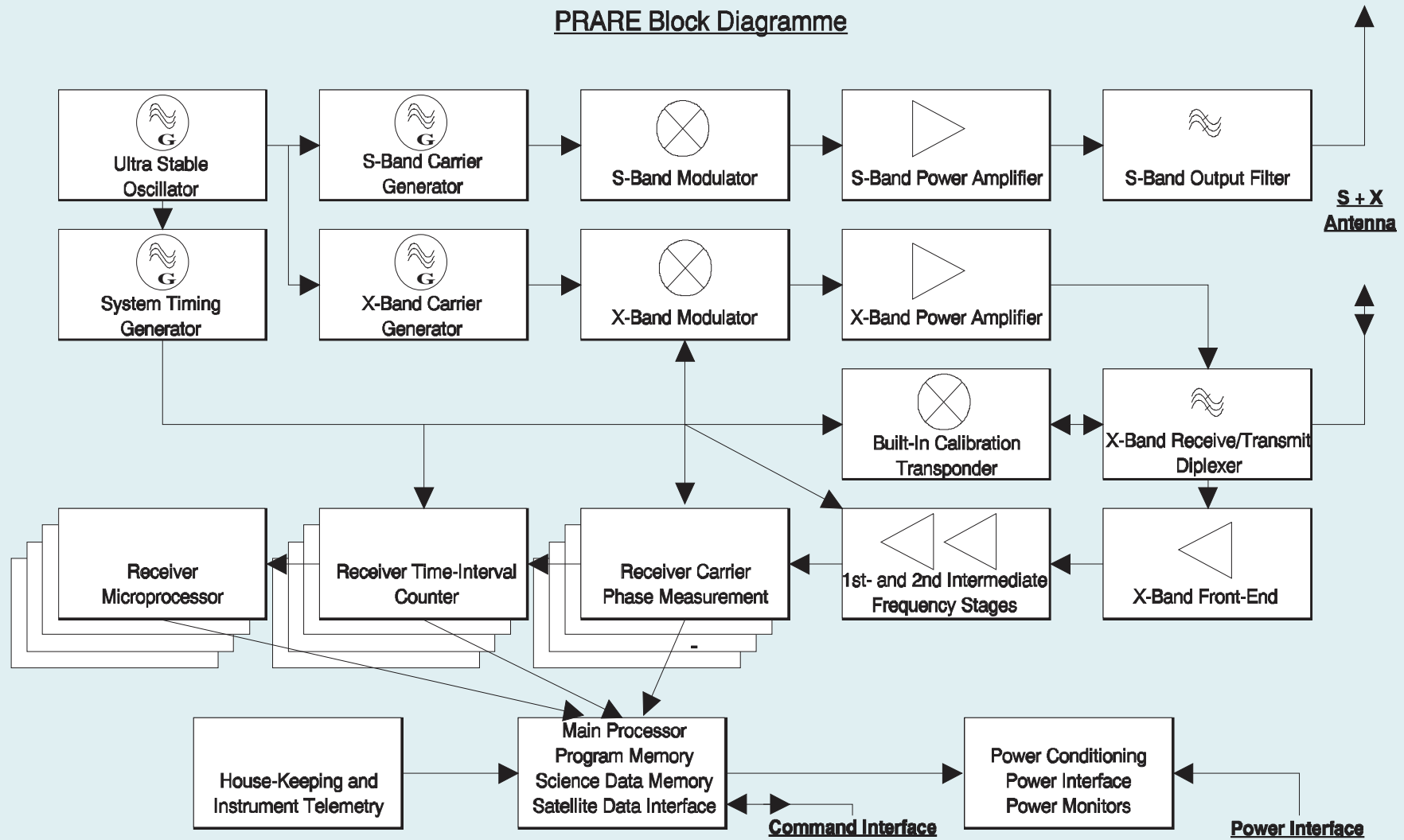
- rozmiary 400x240x180 mm,
- masa 17 kg,
- pobór mocy 30/8 W (moda on/by)



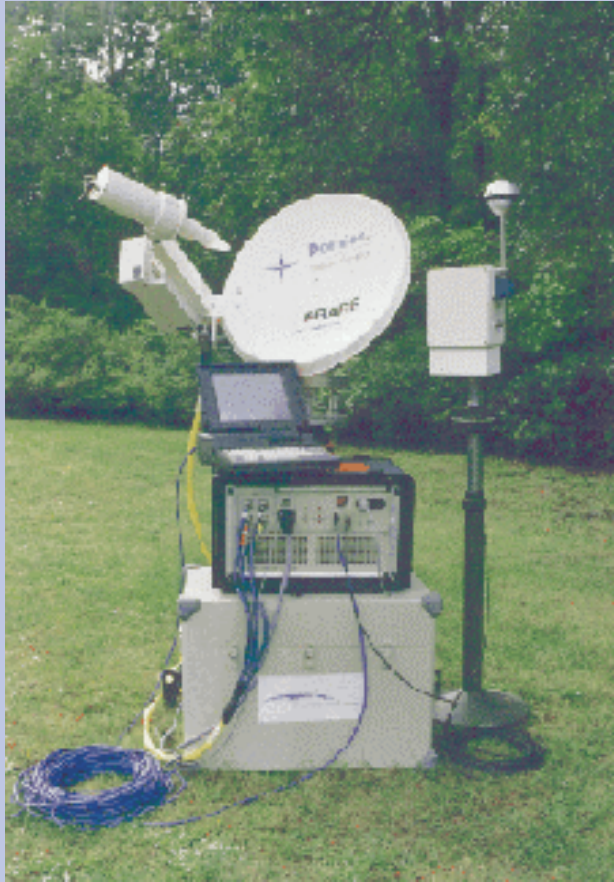
AD 2001.04



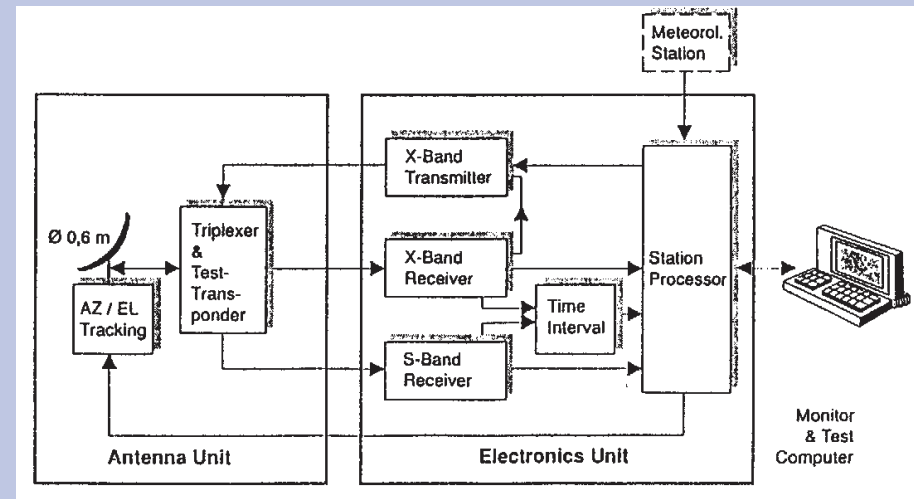
PRARE Block Diagramme



Stacje – anteny naziemne

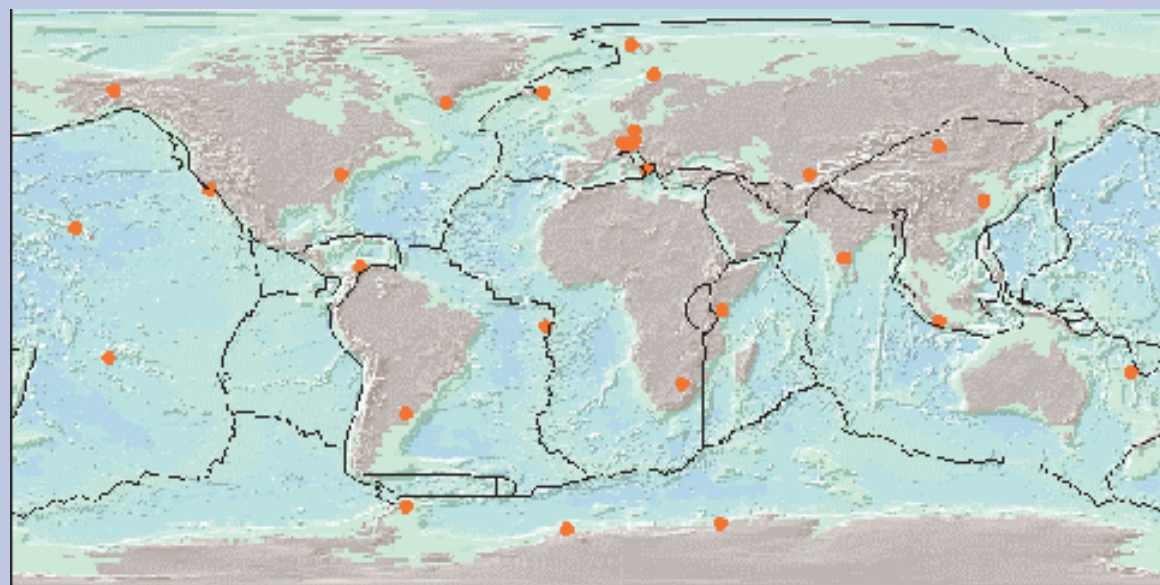


- 60 cm paraboliczna antena,
- montaż azymutalny, śledzący,
- masa anteny 45 kg,
- elektronika (560x560x300 mm, 35 kg)





**Stacje - anteny PRARE
wykonane w Dornier**

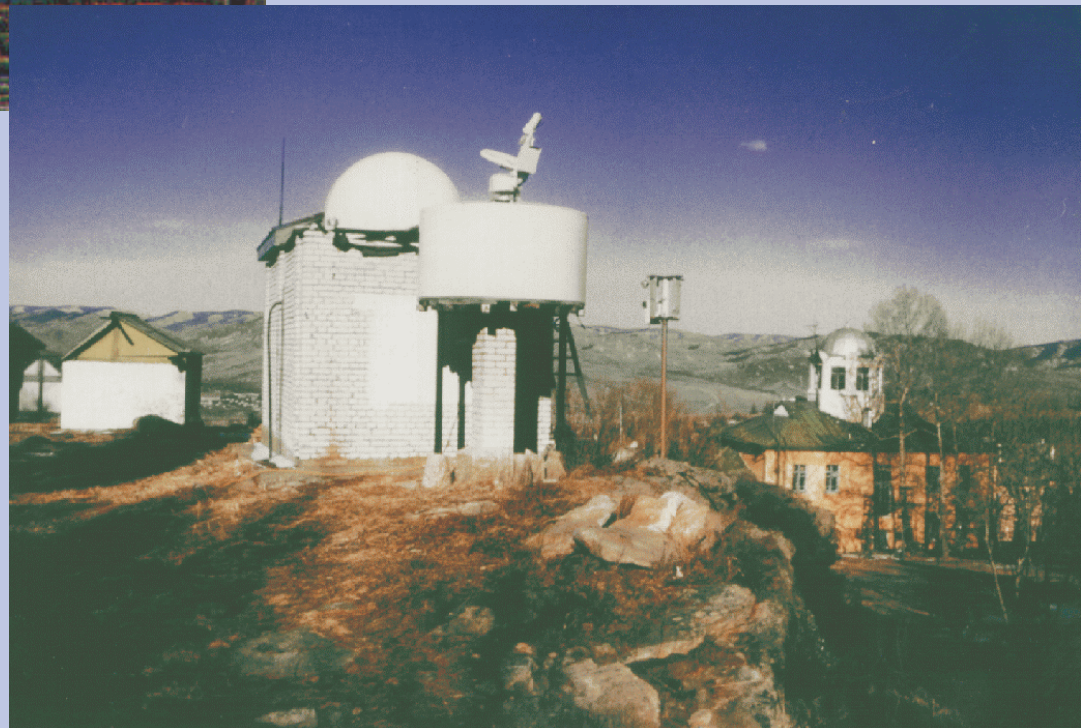




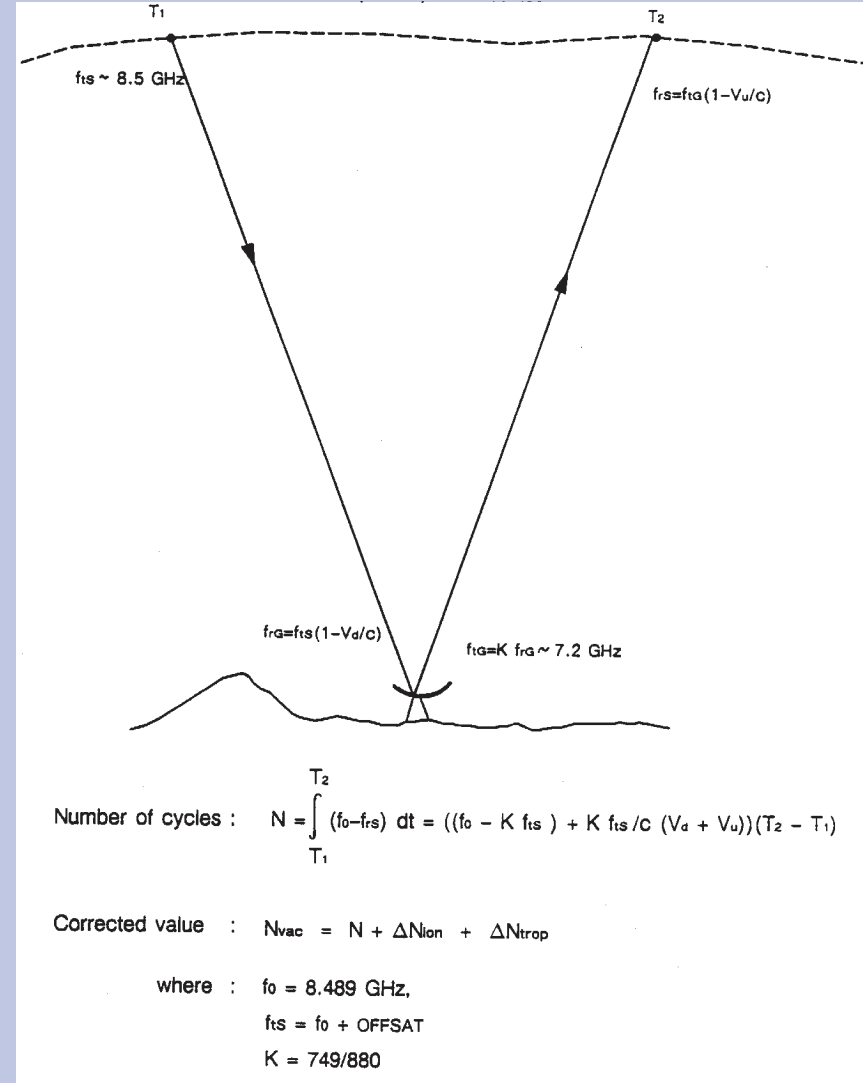
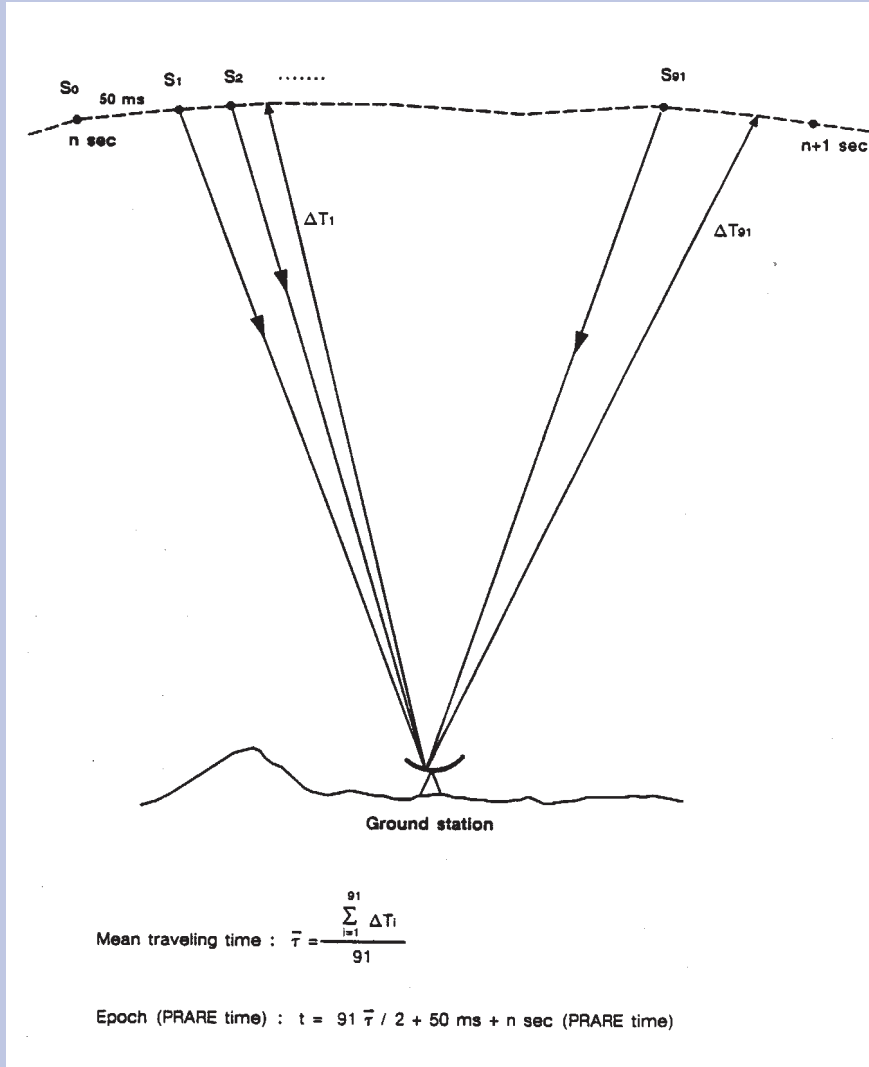
Anteny PRARE

Mongolia

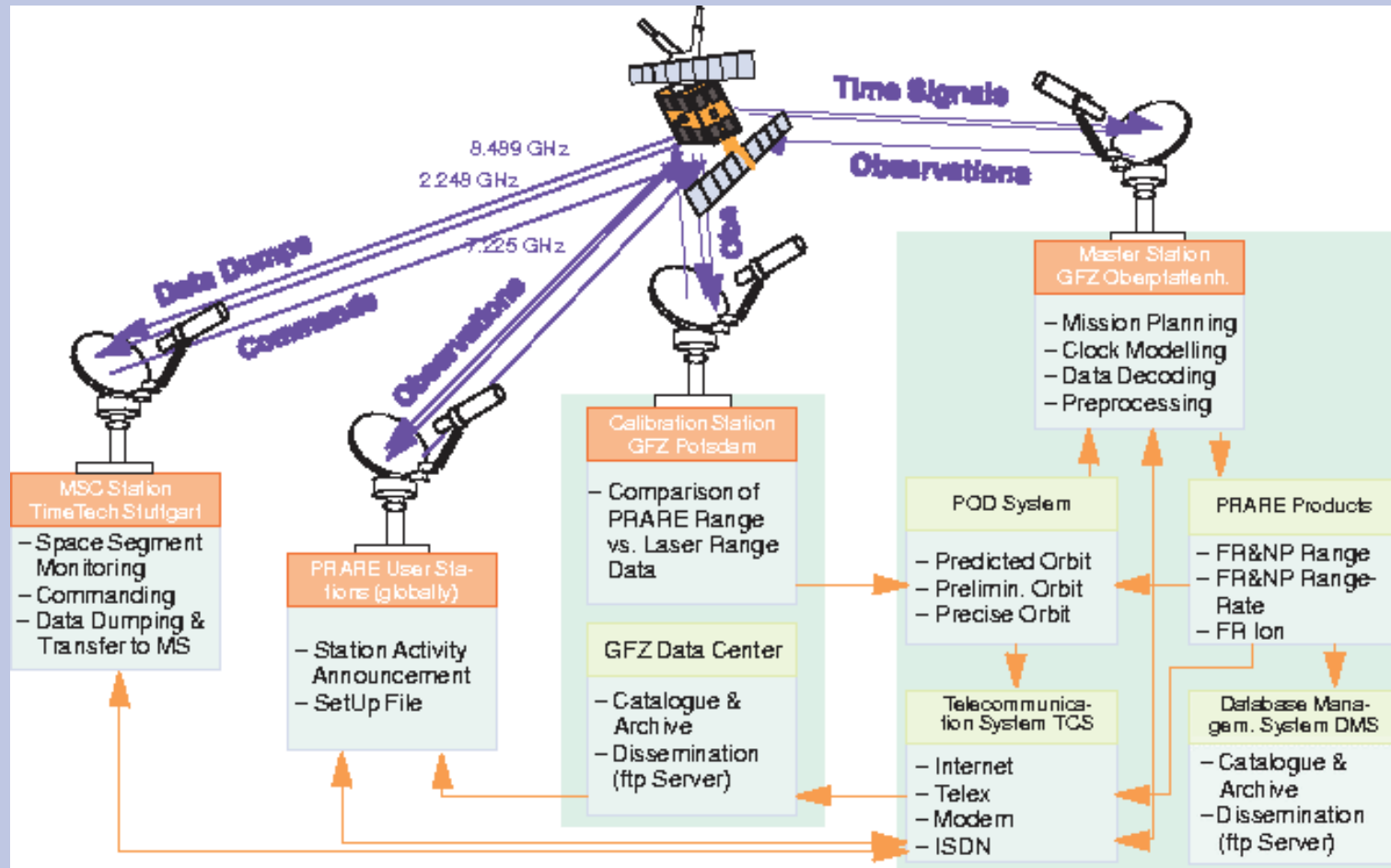
Antarktyda



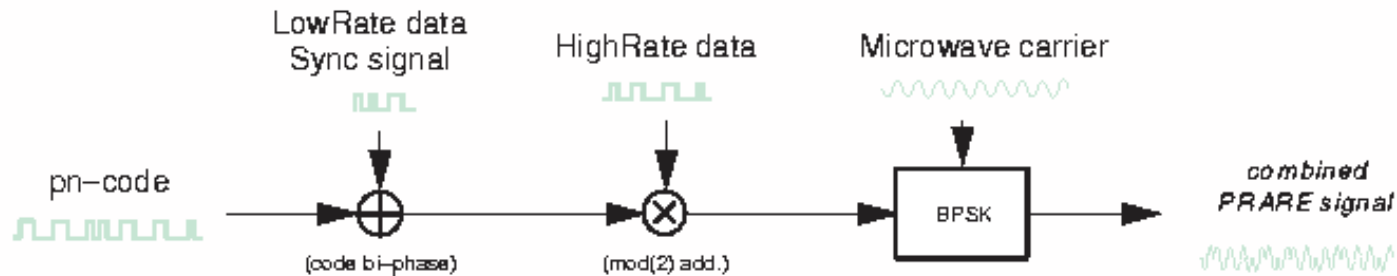
Przebieg pomiaru odległości i prędkości radialnej



Funkcjonowanie systemu PRARE



Sygnal PRARE

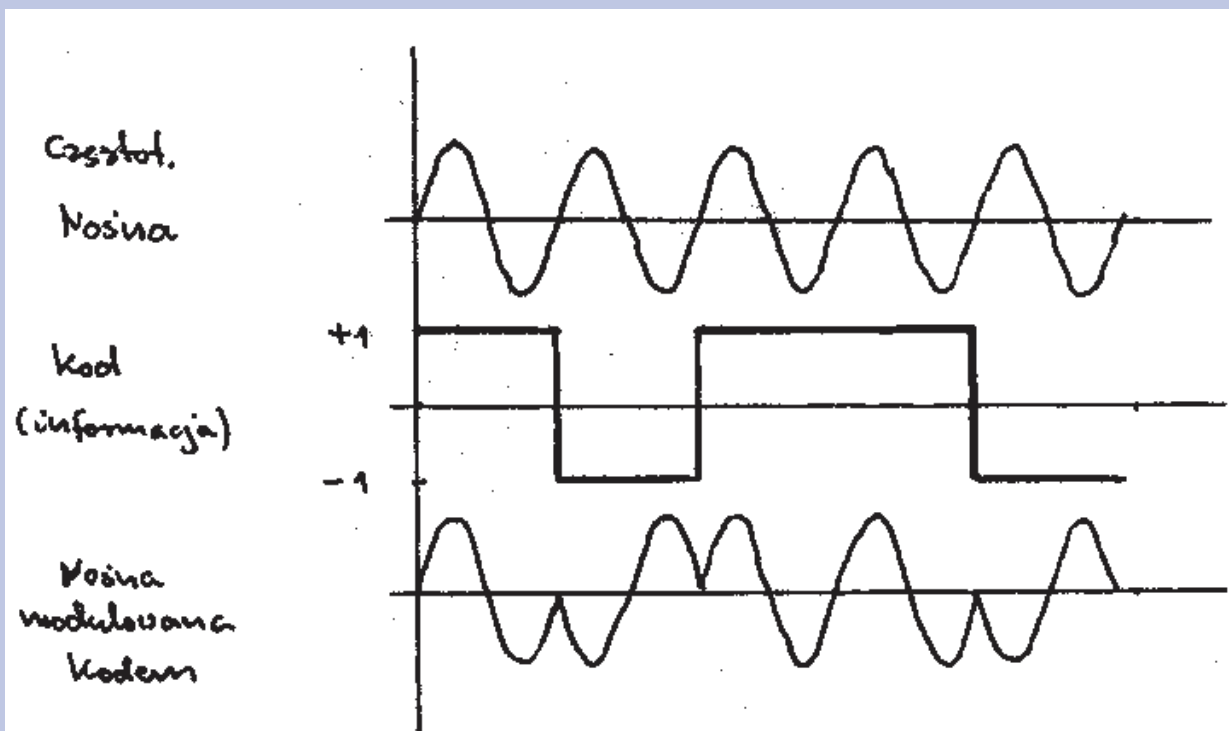


- **pn-codes:** X-band = 10 MHz, S-band = 1 MHz
- **Synchronization signal:** X-/S-band = 8-bit BARKER-Code (10111000)
- **Binary LowRate data:** X-/S-band = 8 bps
- **Binary HighRate data:** X-/S-down = 2000/4000(10000) bps (X-up = 1000 bps)
- **Microwave carriers:** X-down = 8.489 GHz, S-down = 2.248 GHz
X-up = $749/880 \times X\text{-down}$ = 7.225 GHz

10111100011001101001110001110001011110001100110100111000111000



A Short Repeating PRN Code Sample

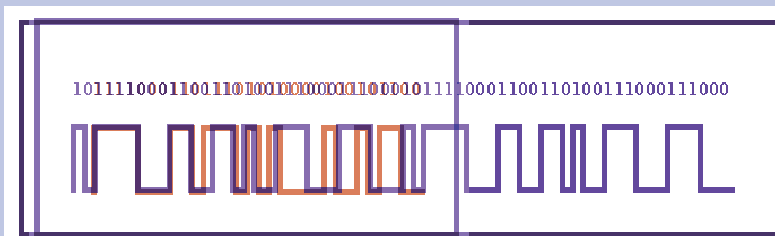
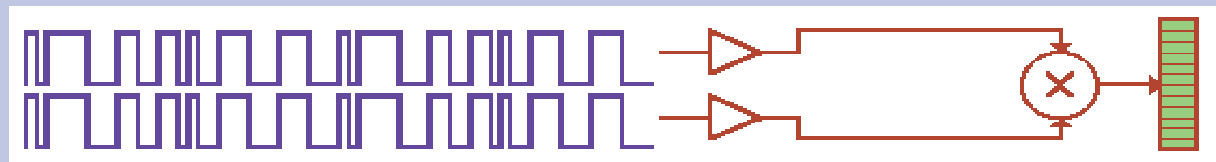


Generacja i zapis danych w pamięci PRARE

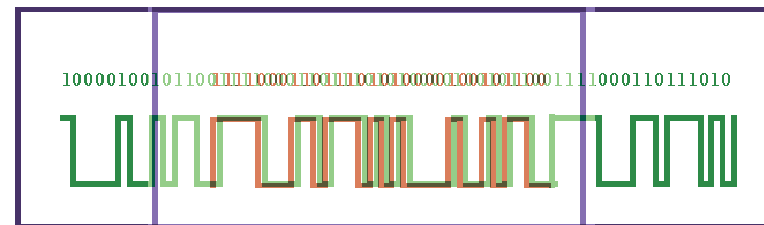
Generation and storage of Data Storage frames. (After Griech 1993).

Name	Length	Generated at	Stored at
PRARE time	4	slot 0-9, PT60s=40	same second
Dummy frame	0	slot 0-9	same second
Receiver data	13,25,37,49	slot 2, if data available	same second
Ground station + receiver number	2	slot 2, if transition to LOCK	same second
Memory error	3	slot 0-9, detection time	some 10PPS later (max. 5)
Ephemeris time	5	slot 2, PT60s=0	same second
LR minute frame	60	slot 0 at PT60s=0	PT60s=20
Ground station position	17	slot 2 if ground station becomes visible; only one position per second is stored	same second
House keeping data	92	slot 5, PT60s=59 (or 0 if high CPU load)	PT60s=0

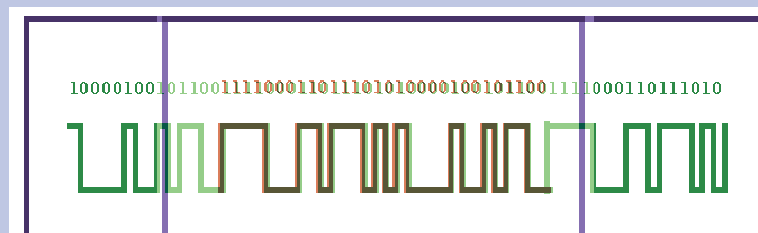
Korelowanie kodów sygnału emitowanego i odebranego



No Correlation with a Different PRN Code

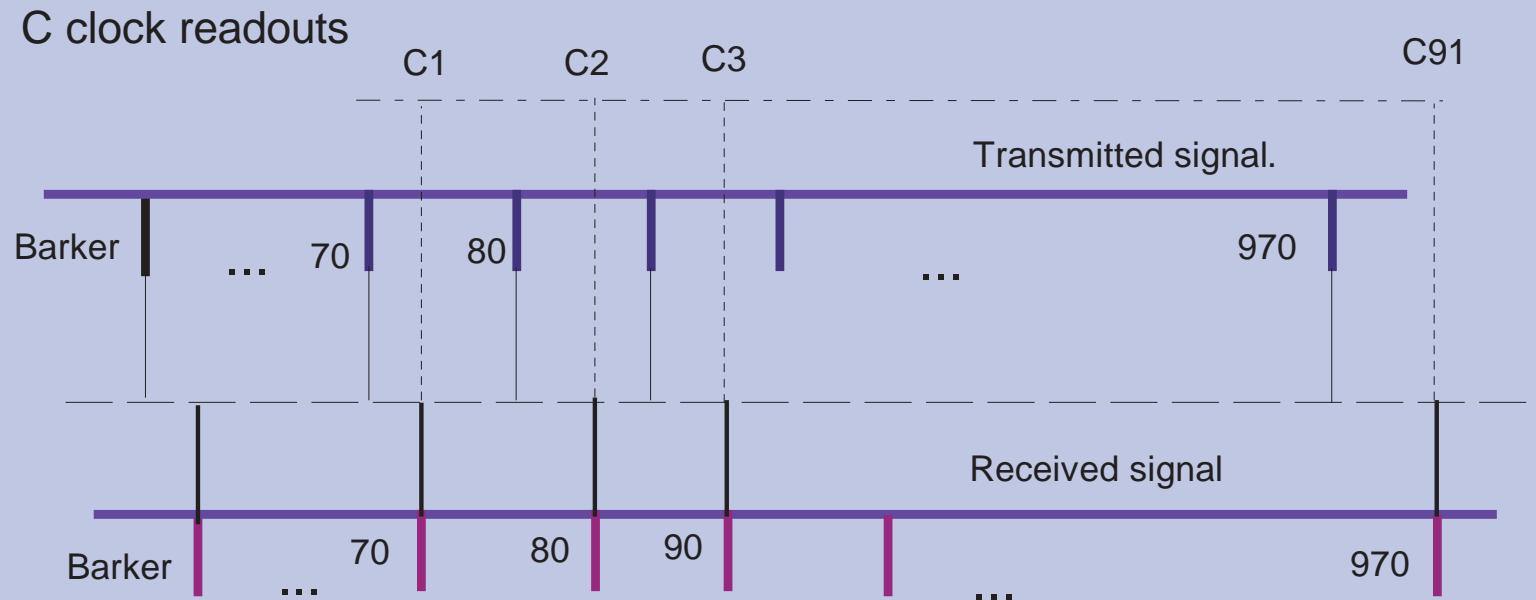


Partial Correlation of Identical Receiver and Satellite PRN Codes

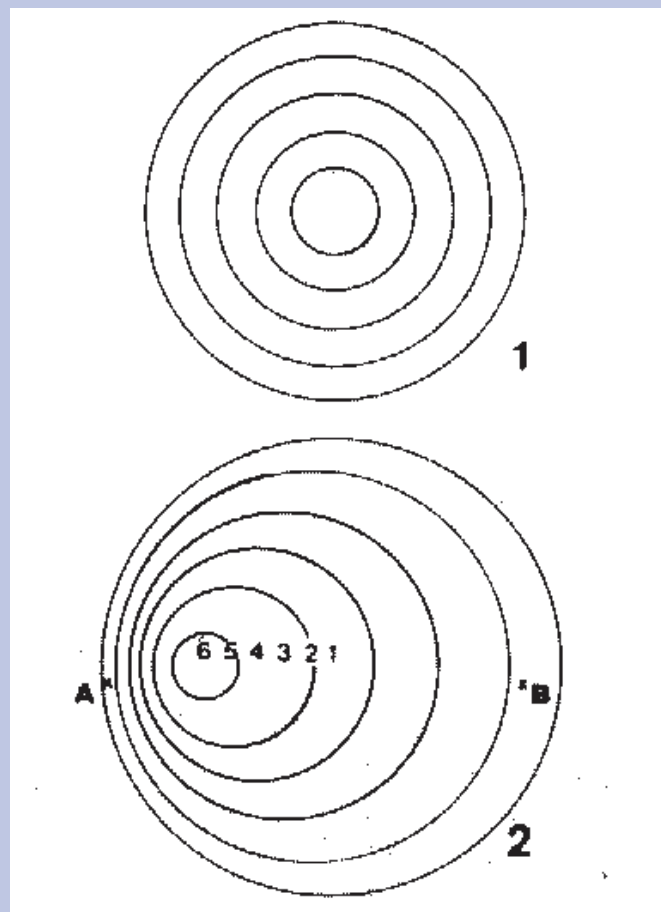


Full Correlation (Code-Phase Lock) of Receiver and Satellite PRN Codes

Zasada pomiaru odległości



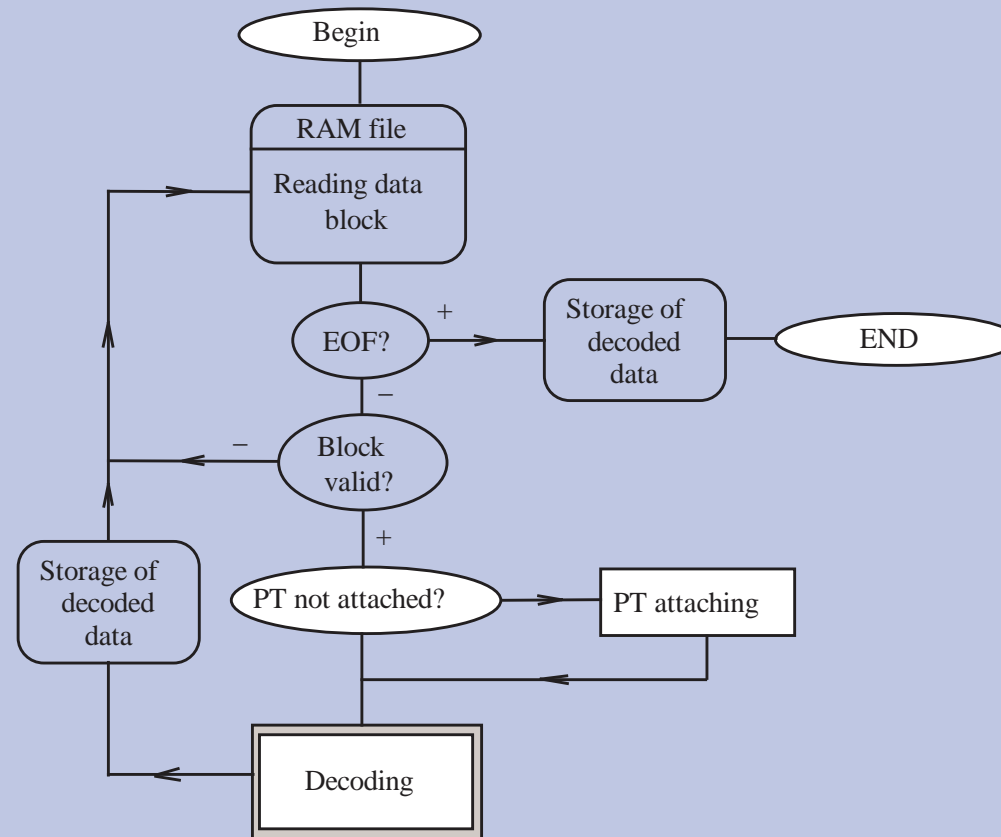
Zjawisko przesunięcia Dopplera fali E-H

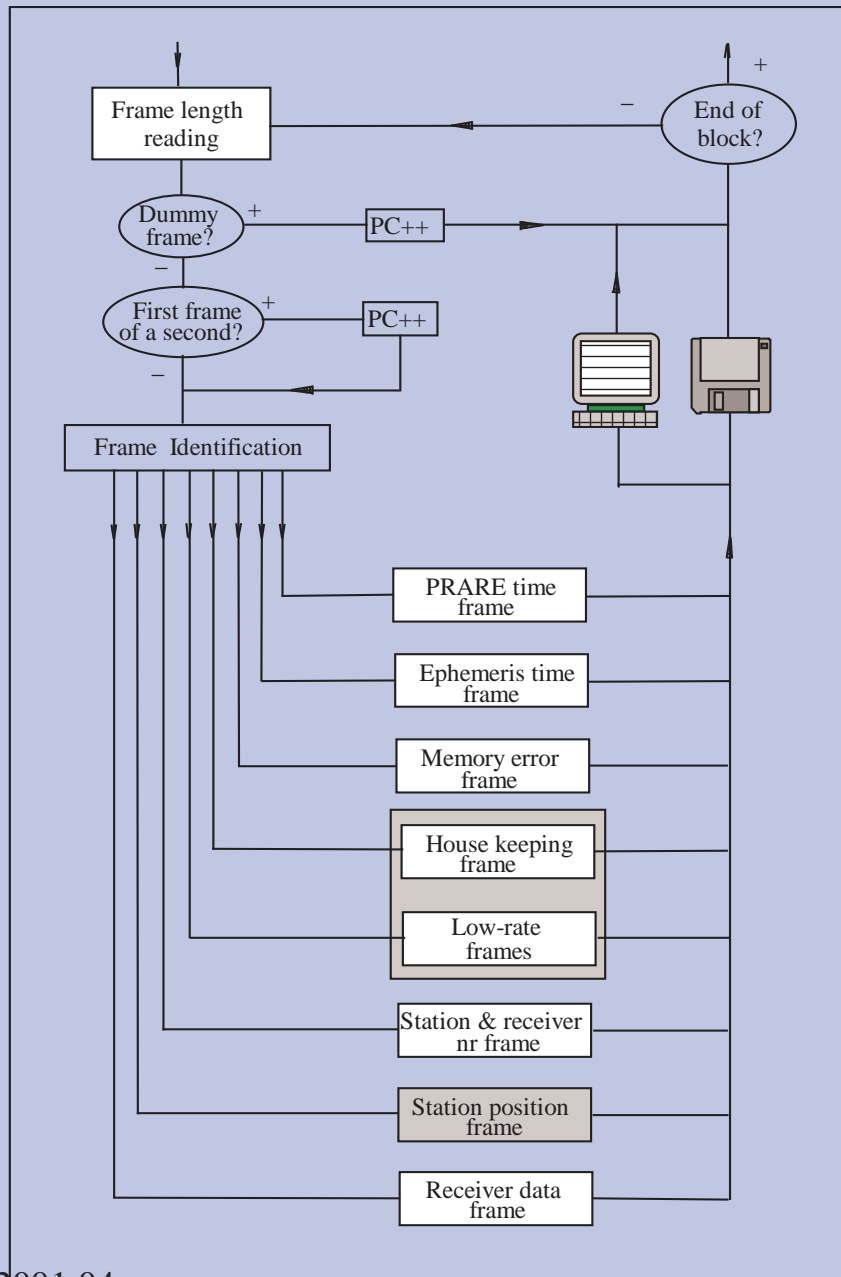


Ramki danych PRARE

Name	Length	Generated at	Stored at
PRARE time	4	slot 0-9, PT60s=40	same second
Dummy frame	0	slot 0-9	same second
Receiver data	13,25,37,49	slot 2, if data available	same second
Ground station + receiver number	2	slot 2, if transition to LOCK	same second
Memory error	3	slot 0-9, detection time	some 10PPS later (max. 5)
Ephemeris time	5	slot 2, PT60s=0	same second
LR minute frame	60	slot 0 at PT60s=0	PT60s=20
Ground station position	17	slot 2 if ground station becomes visible; only one position per second is stored	same second
House keeping data	92	slot 5, PT60s=59 (or 0 if high CPU load)	PT60s=0

Dekodowanie bloków danych PRARE



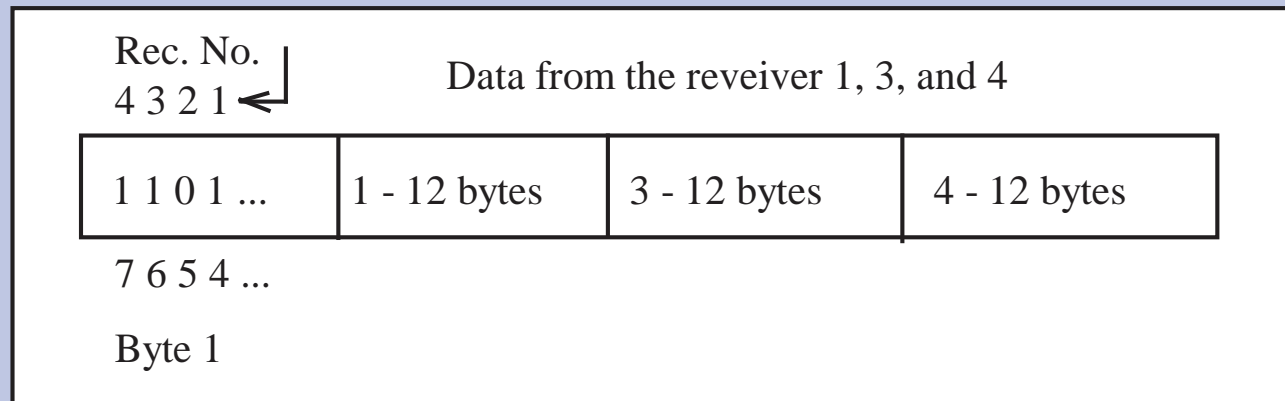


**Data Storage Dump
block decoding.**

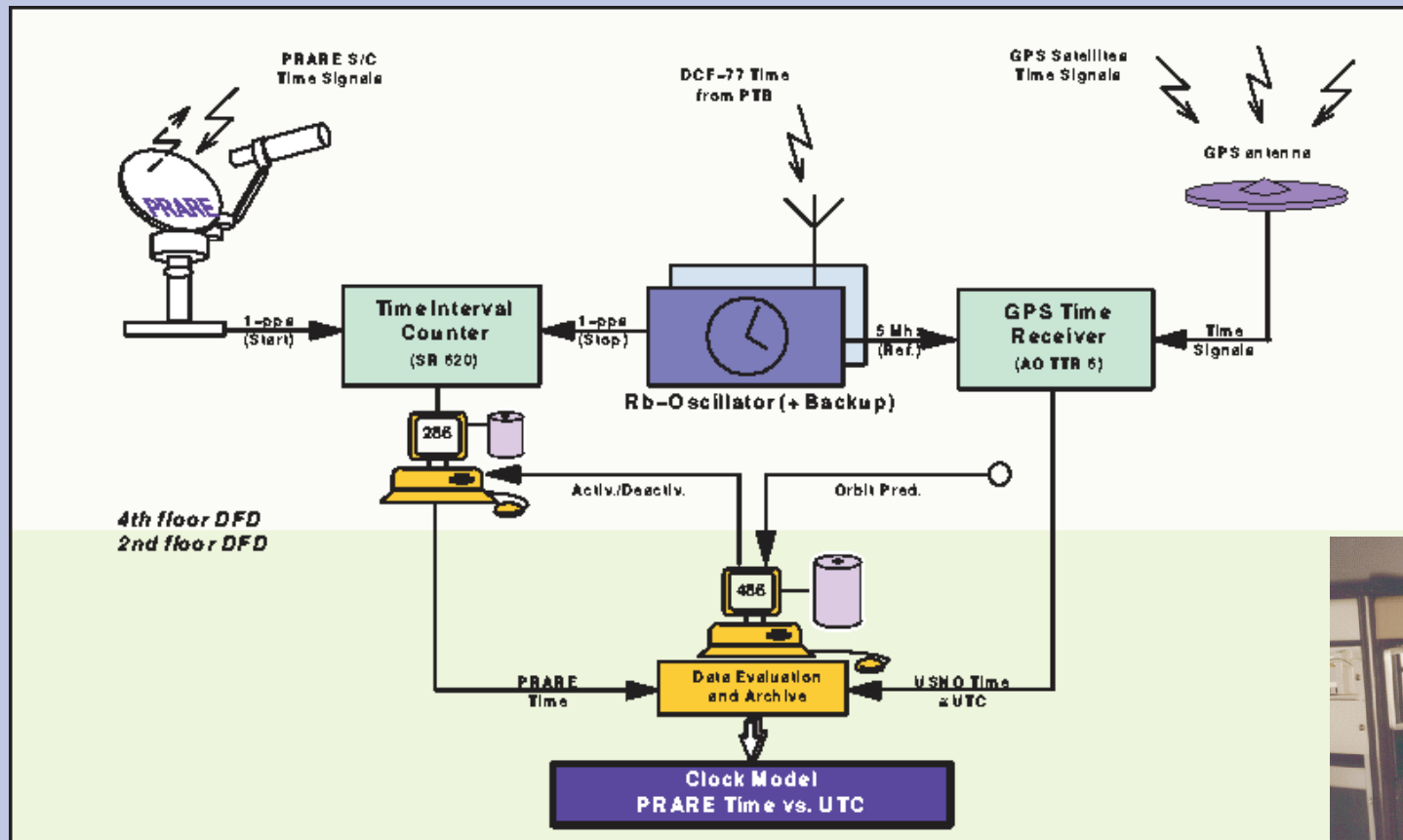
Dekodowanie danych systemowych (housekeeping)

Power :	U sec	I perm	I oper	S-TX	X-TX
U Prim :	113.0 V	132.00 V	114 mA	ON	ON
I Prim :	90.00 A	133.00 V	95 mA	109 mA	I [mA] 46 78
Temp PS:	138.0°C	131.00 V	118 mA	155 mA	P[dBm] 71.00 93.00
Temp SW:	140.0°C	71.00 V		Temp	143.0°C 145.0°C
Receiver	Channel: 1	Channel: 2	Channel: 3	Channel: 4	VCOs [V] °C
	LSPCsKSu	LSPCsKSu	LSPCsKSu	LSPCsKSu	176: 0.00 22.0
RX-STATUS	... 0188	... 0188	... 0188	... 0188	2248: 0.00
I 5V/9V[mA]	156 124	153 122	154 118	155 123	8489: 185.00
T CODE[°C]	147.0	144.0	146.0	145.0	9.99: 67.00128.0
T DLL [°C]	123.0	128.0	123.0	120.0	-Status-
Dopp. Freq	0.0	0.0	0.0	0.0	LowRate 5
Ust [Dopp]	182.00	192.00	189.00	185.00	Link OK
Code Freq	0.0000	0.0000	0.0000	0.0000	Operational
Ust [Code]	160.00	150.00	159.00	150.00	
AGC [V]	128.00	142.00	139.00	148.00	PCnt: 0
Lock/Ampel	Search 0	Search 0	Search 0	Search 0	dt: 0.000s
Ref.Ra.[m]	0.00	0.00	0.00	0.00	CrcError: 0
Dist [m]	0.000	0.000	0.000	0.000	TimeOut: 0
Mean [m]	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	X-RX :140.0°C
Nr: Udata	0: 0	0: 0	0: 0	0: 0	X-AGC: 150.00
					16d 19h 23m 0.0s
Test Transponder:	OFF	144.0°C	251.0mA	USO: 134.0°C	Rth: 0 53195.0"
ANNA commanding and status display					11/01/15 12/04/1993 3

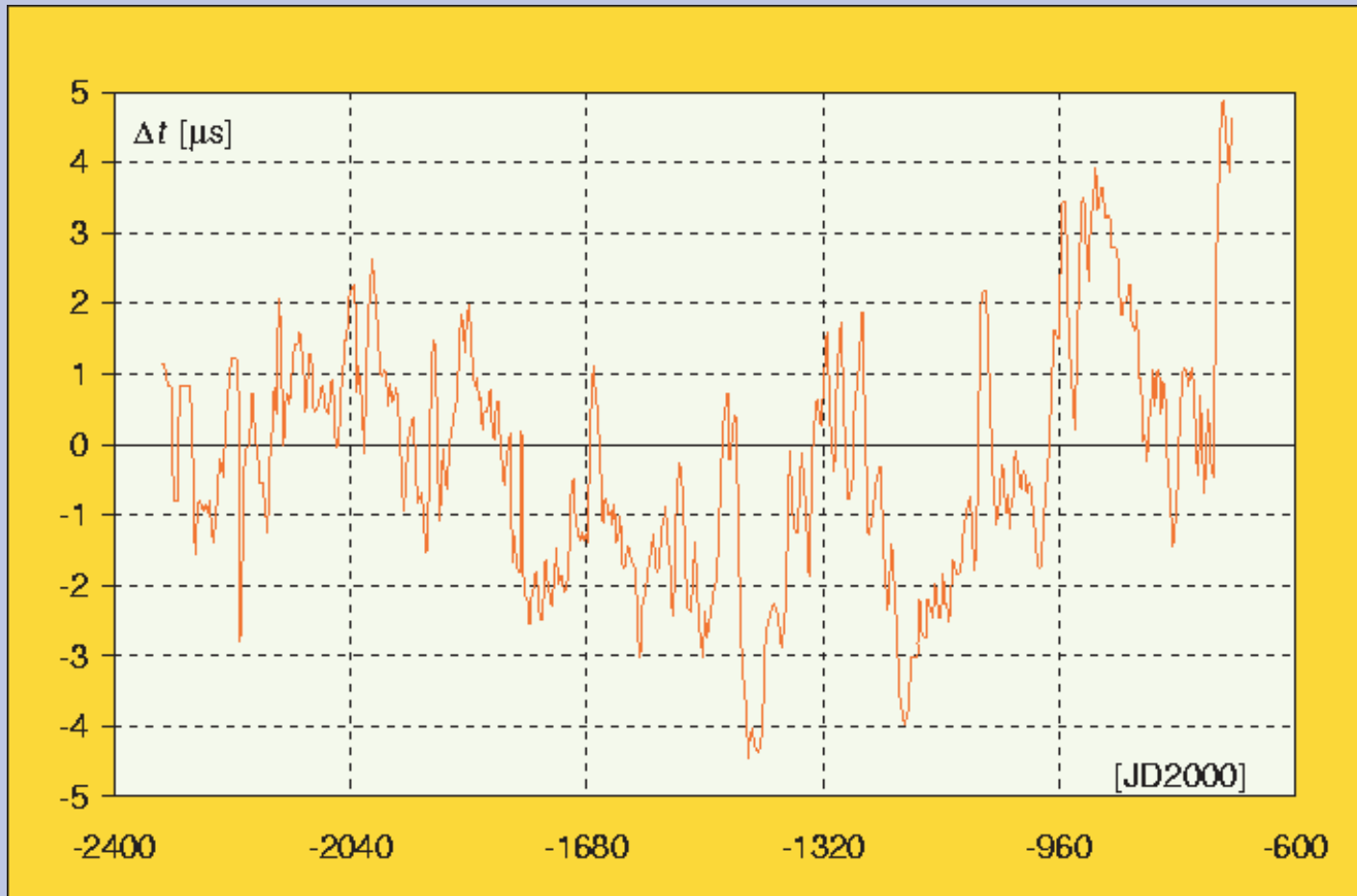
Format danych geodezyjnych



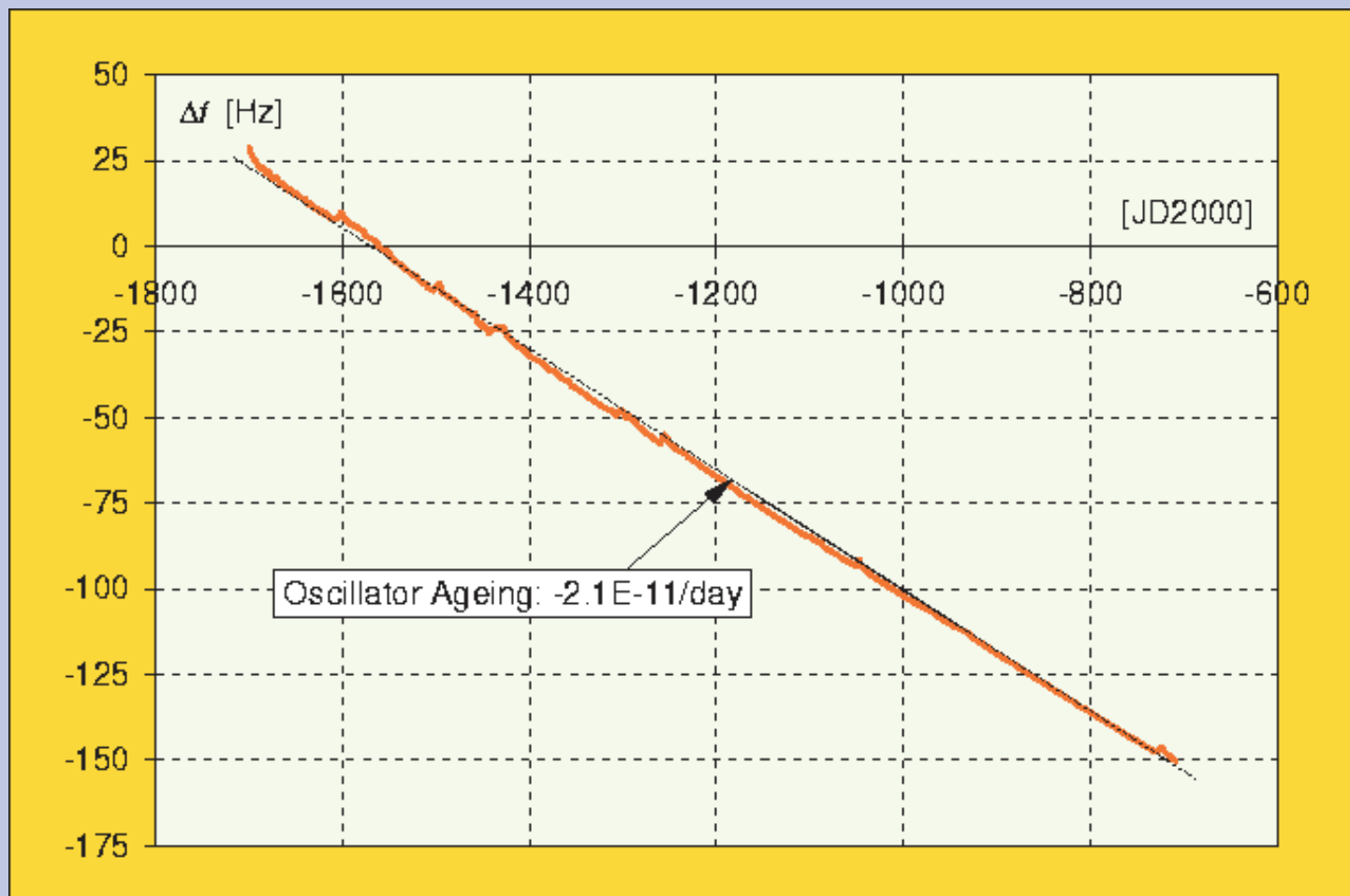
Skala czasu PRARE i UTC



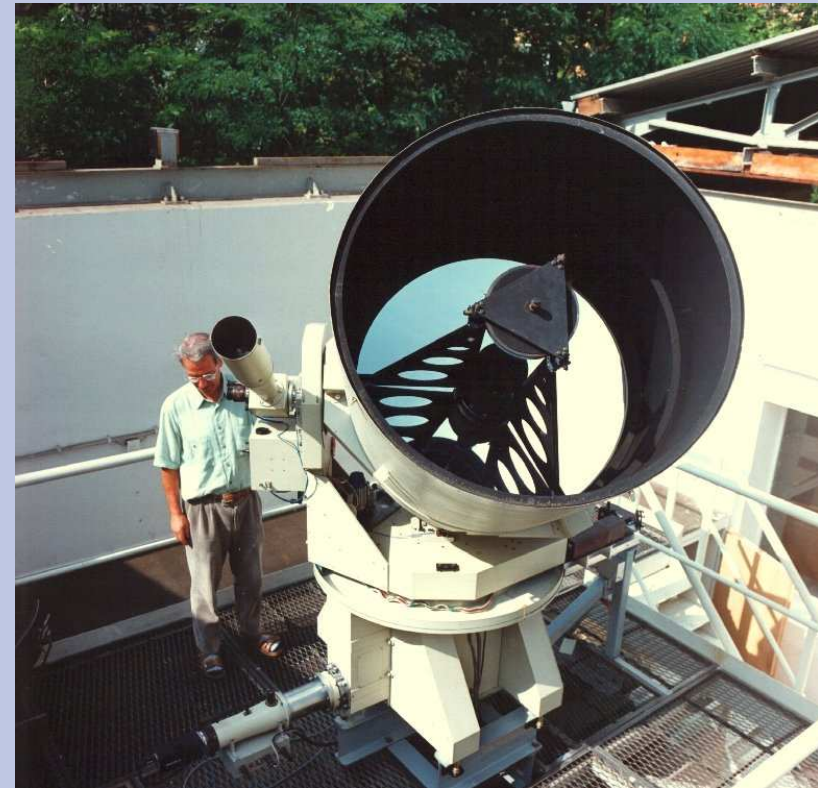
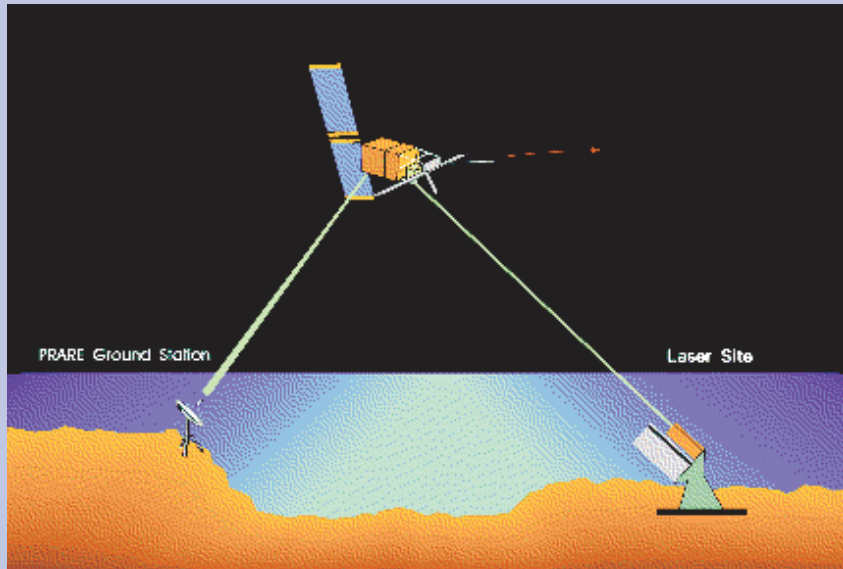
Poprawka zegara PRARE



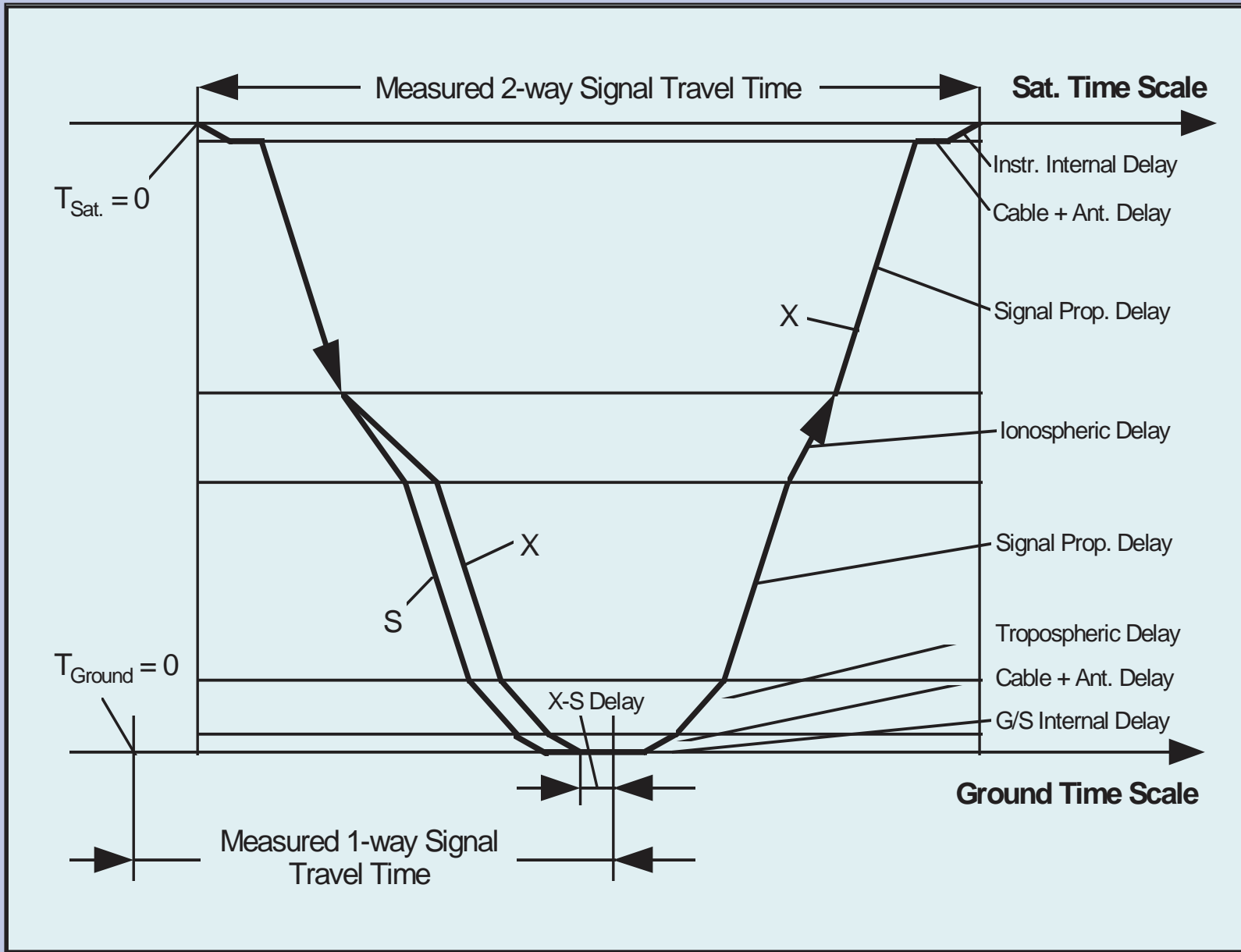
Zmiany częstotliwości oscylatora PRARE



Kalibracja systemu PRARE

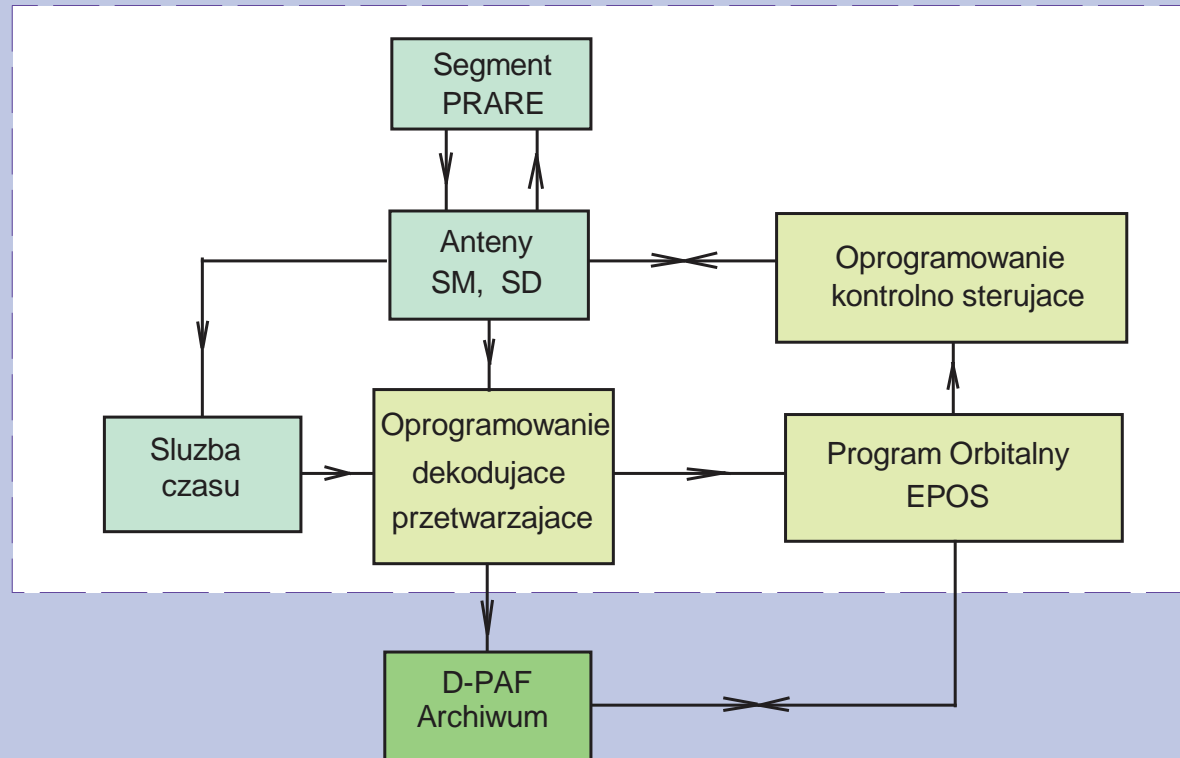


Dalmierz laserowy GFZ w Poczdamie





PRARE stacja master w DLR Oberpfaffenhofen



Noise Values

1.5 ... 3.2 cm (X-band ranging, 1 measurement/s, corrections due to measurement principle included)
0.05 ... 0.1 mm/s (X-band doppler, 30 s integration time, corrections due to measurement principle included)

Bias Values

< 1 cm (X-band ranging, calibration data applied)
< 0.01 mm/s (X-band doppler, calibration data applied)

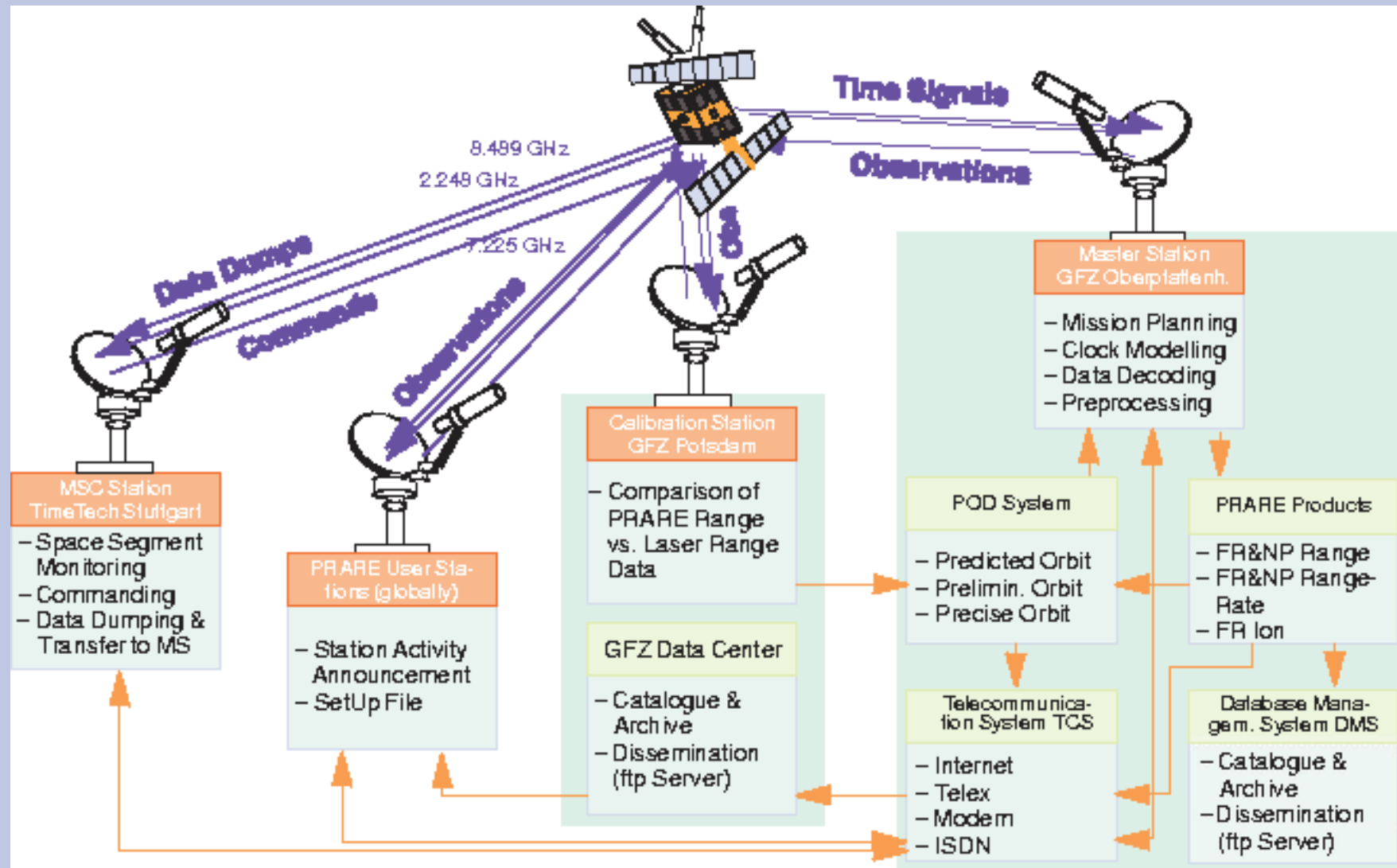
Correction Values

residual ionospheric error: **1 cm**
residual calibration error: **1.5 ... 2 cm**
residual tropospheric error: **2 ... 5 cm**
residual phase and mass centre error: **1 cm**
< 0.01 mm/s for X-band doppler error

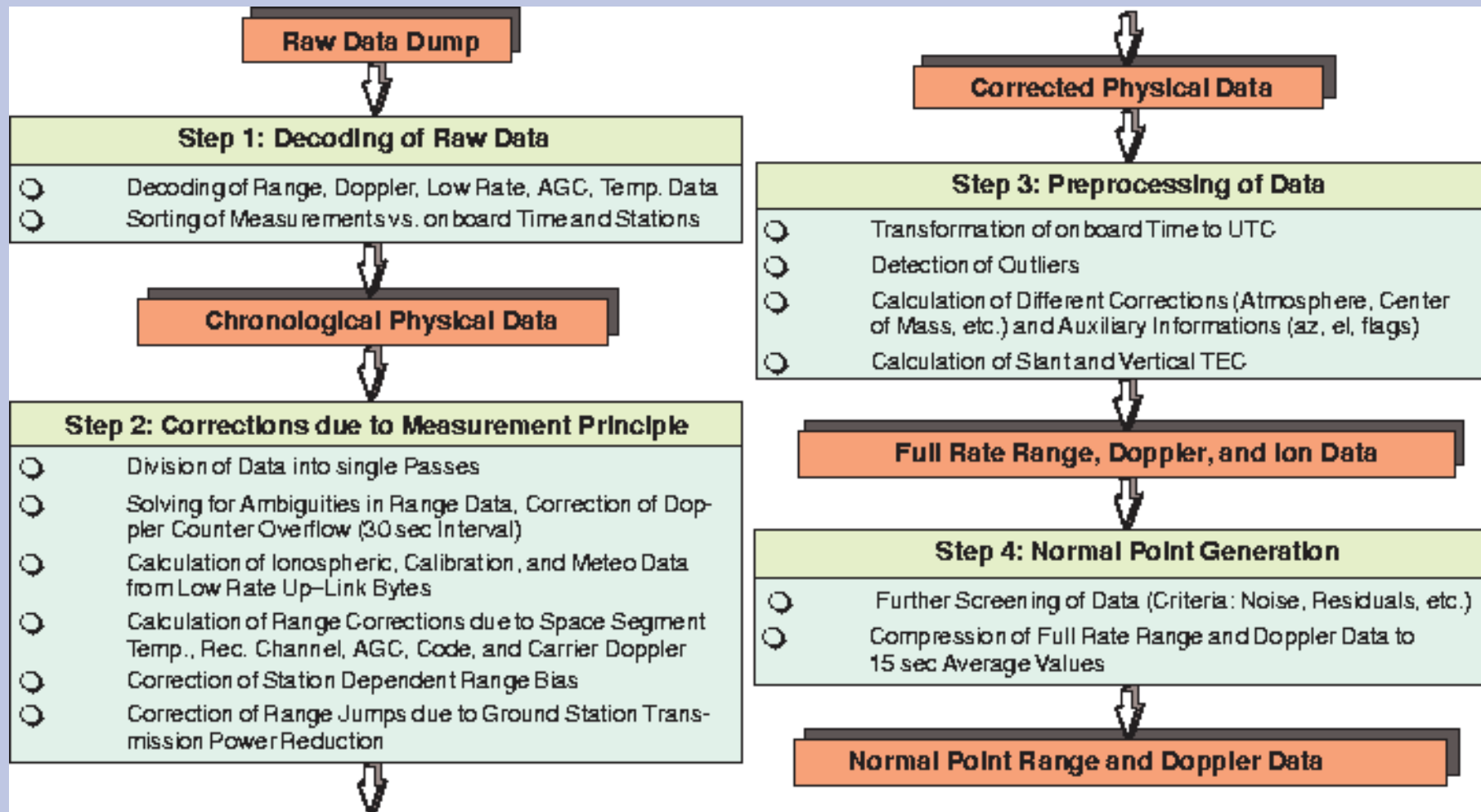
Ranging Accuracy (root squared sum): 2.5 ... 6.5 cm

Range-Rate Accuracy (root squared sum): 0.1 mm/s

Struktura systemu PRARE

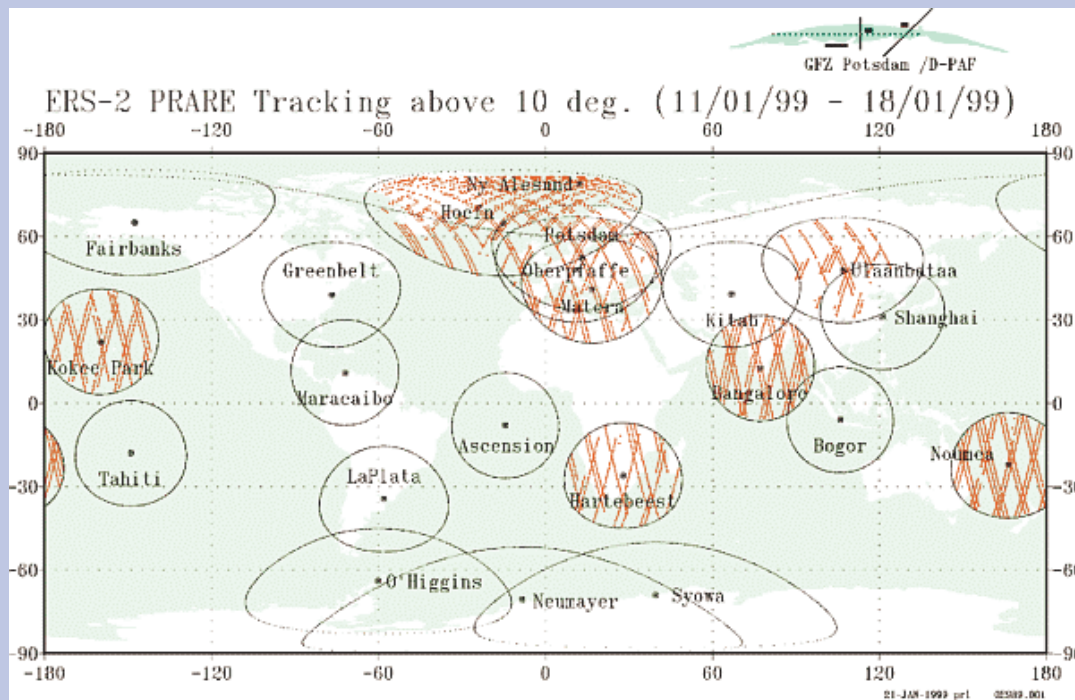


Produkt PRARE

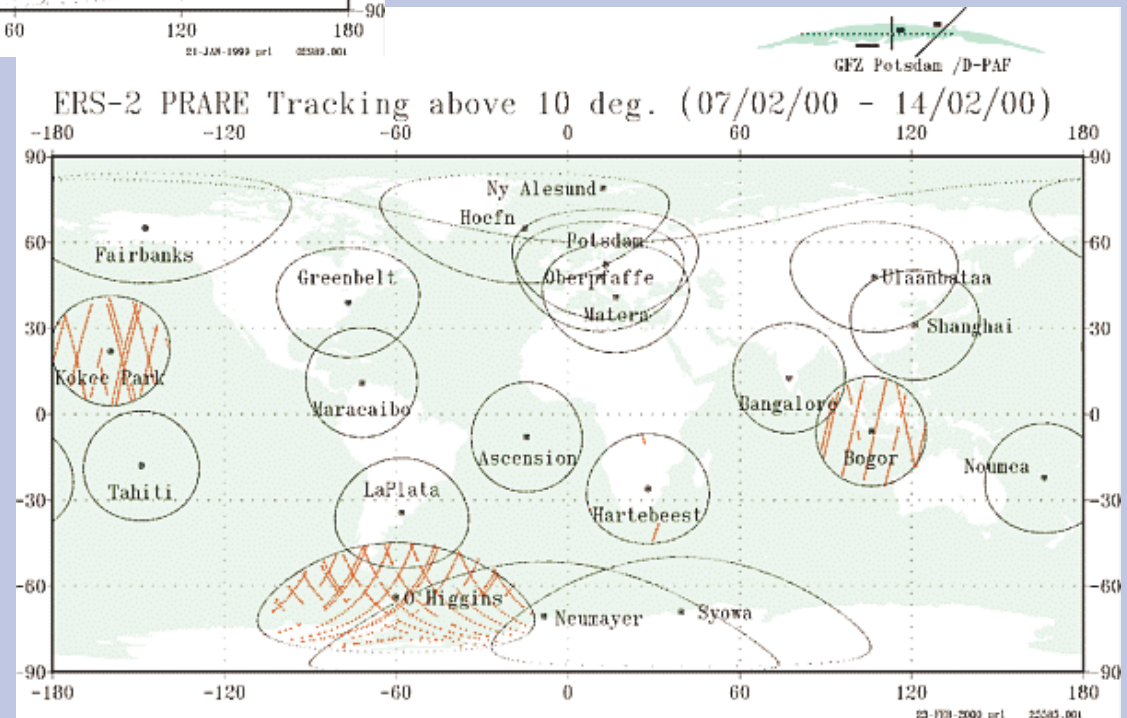


Produkt PRARE: pomiary jonosferyczne

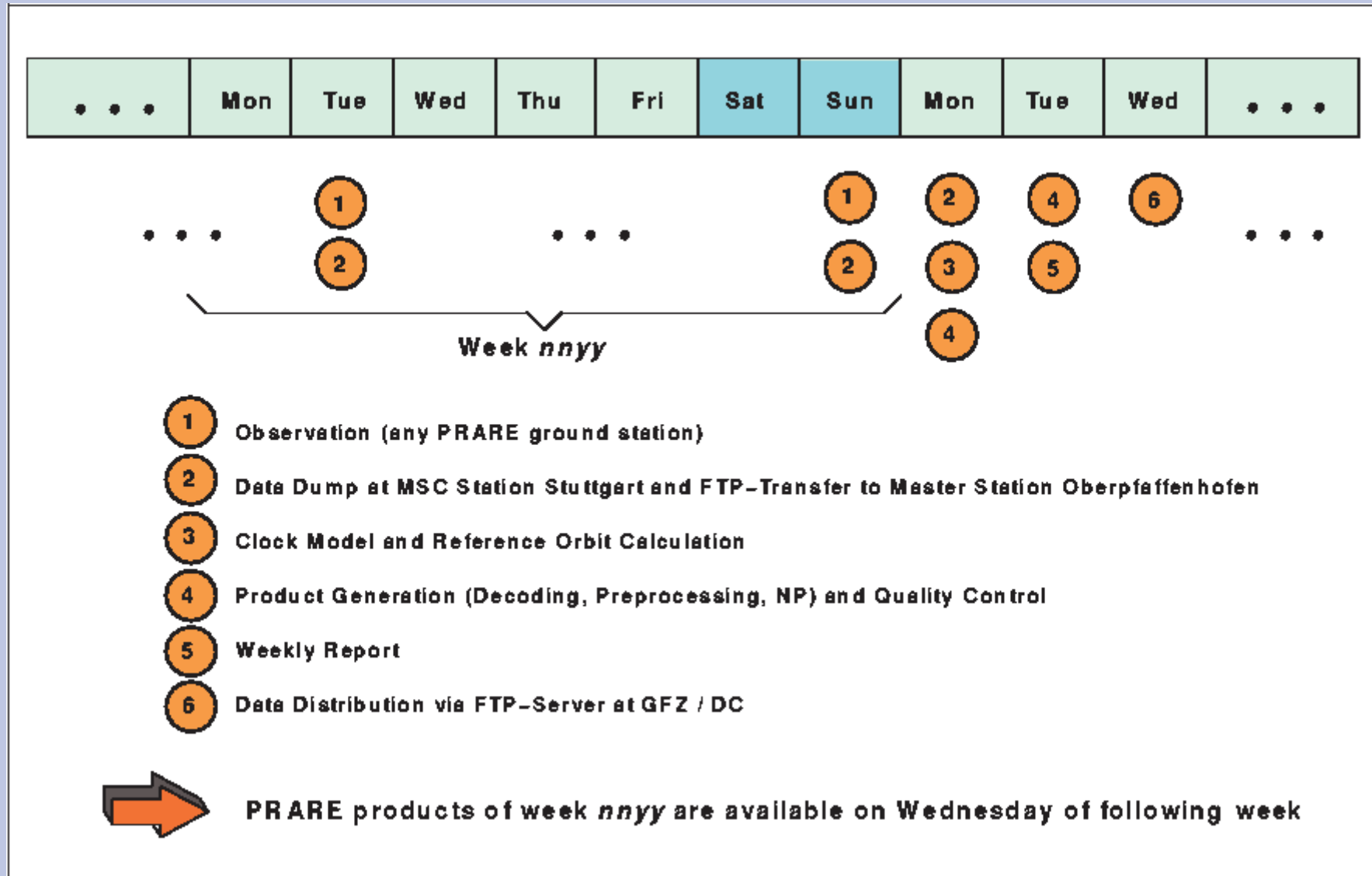
PRARE Ionospheric Data Record						
=====						
No.	Name	Offset	Format	Unit	Res.	Description
1	RECKEY	0	A8	-	-	'PRAREION'
2	NSATEL	8	I7	-	-	satellite ID (COSPAR)
3	JAHHR	15	I2	y	1	year of century
4	ITAG	17	I3	d	1	day of year
5	SEC	20	F12.7	sec	10 ⁻⁷	second of day
6	IT1	32	I1	-	-	epoch event = 1 : satellite emission time = 2 : satellite receiving time
7	IT2	33	I1	-	-	epoch time scale = 3 : UTC(USNO) = 5 : UTC(BIPM) = 7 : UTC(approximated)
8	NUMSTA	34	I5	-	-	station ID (COSPAR)
9	ICAMP	39	I4	-	-	campaign ID (instrument no. (I2) + occupation no. (I2))
10	IAVER	43	I1	-	-	flag for averaging interval = 0 : 4 sec average = 1 : 1 sec average
11	AZIM	44	F5.2	degree	0.01	azimuth at ground station
12	ELEV	49	F5.2	degree	0.01	elevation at ground station
13	RANGE1	54	F12.0	psec	1	one-way travel time
14	PRESS	66	F5.1	hpa	0.1	air pressure at ground station
15	TEMP	71	F4.1	Kelvin	0.1	air temperature at ground station
16	WETT	75	F4.1	%	0.1	air humidity at ground station
17	IONO	79	I7	psec	1	X-band versus S-band travel time delay measurement (1-way space to ground) derived from DRVID
18	TECSLA	86	E11.5	1/m ²	1	total electron content along ray path



PRARE raporty tygodniowe



PRARE dostępność danych



Dystrybucja danych pomiarowych

FTP Server GFZ Potsdam /Data Center

/home/pub/kg/PRARE/mission/...

Data: .../19yy/WEEKwwyy_r/III_hh_yyww_rev.Z

User Info: .../PRARE2_INFO/...



User with individual account and pwd

mission = (NETEOR3; ERS2)

yy = year (94;95;...)

ww = no. of week (1...53)

r = revision (0...9)

hh = station h/w number (1...29)

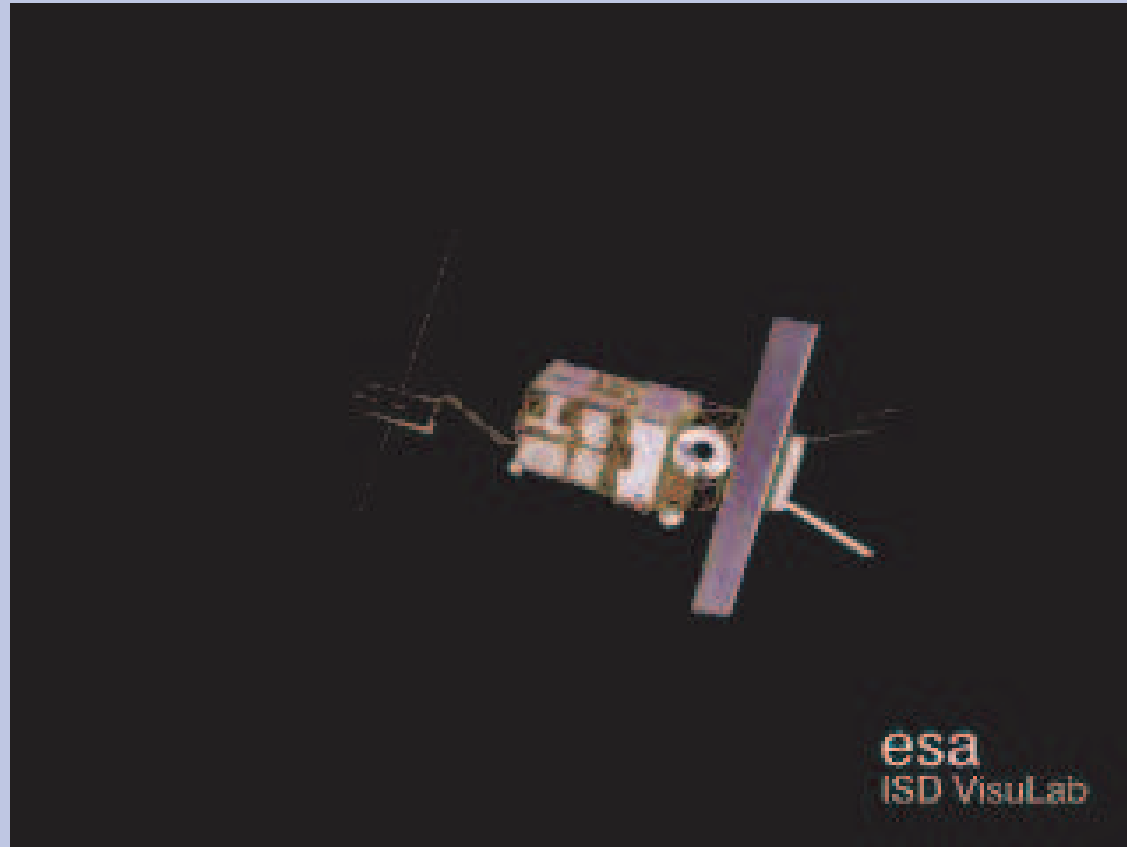
Z = data are compressed with UNIX compress command

III = product identifier:

ION = ionospheric product

NPR = NP range product

NPD = NP doppler product



K O N I E C