



Learn the Basics of NASA Salinity

Thomas Meissner

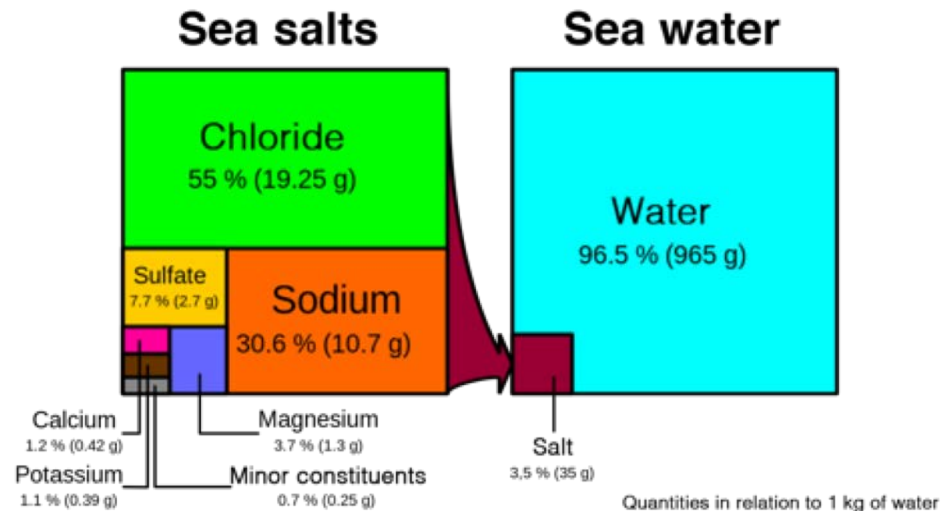
Remote Sensing Systems

Senior Research Scientist



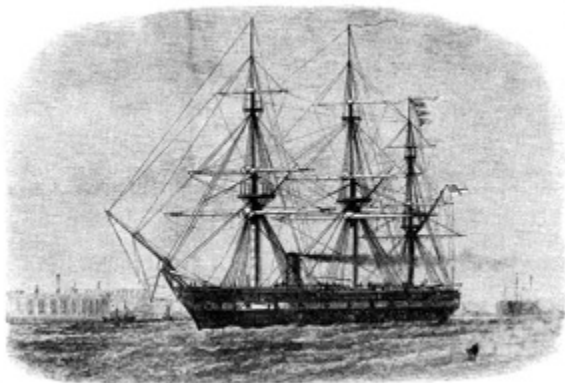
Salinity Science

- Salinity is a measure of dissolved salts in seawater
 - Average open ocean salinity is about 35 grams of salt per 1000 grams of seawater
 - Salinity is expressed as *Practical Salinity Units* (PSU) or is a dimensionless unit ("35")

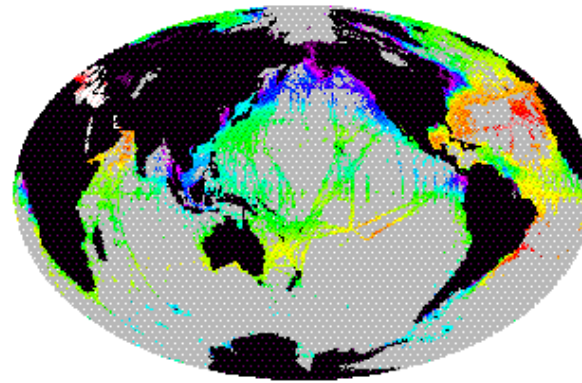


Salinity Science

- Historically, salinity was measured along ship routes
 - General patterns of salinity were known:
 - High salinity in gyres and evaporative basins (Mediterranean Sea)
 - Low salinity along tropical rain bands, near rivers, high latitudes
- Argo profiling floats began in 2000
 - Make vital salinity measurements over the globe



HMS Challenger (1858)

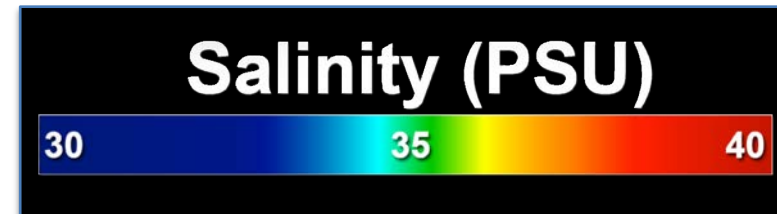
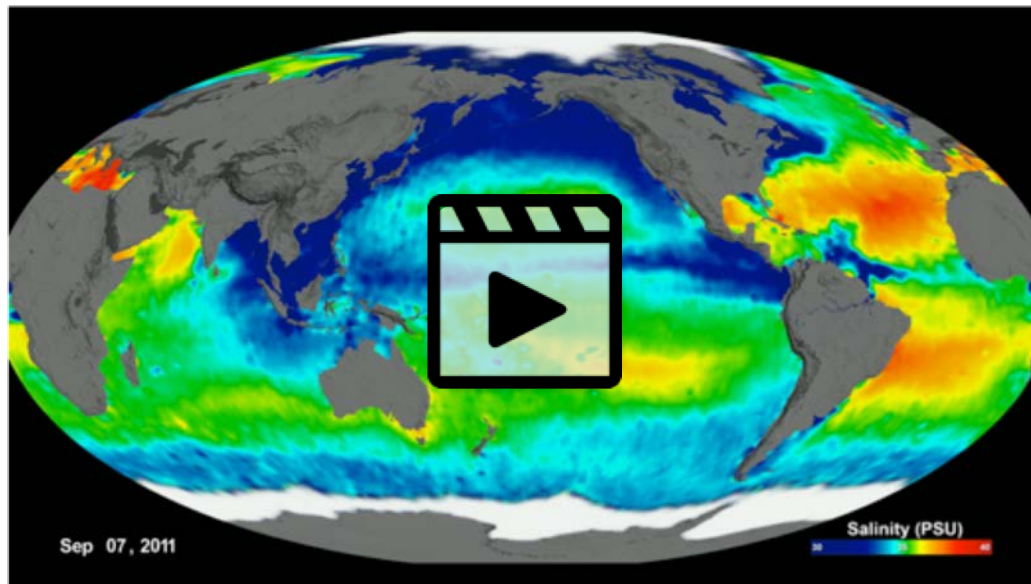


100 years of Sea Surface Salinity (SSS) measurements



Salinity Science

- NASA's first dedicated salinity instrument, *Aquarius*, provided weekly global maps
 - These revealed areas with high temporal variation

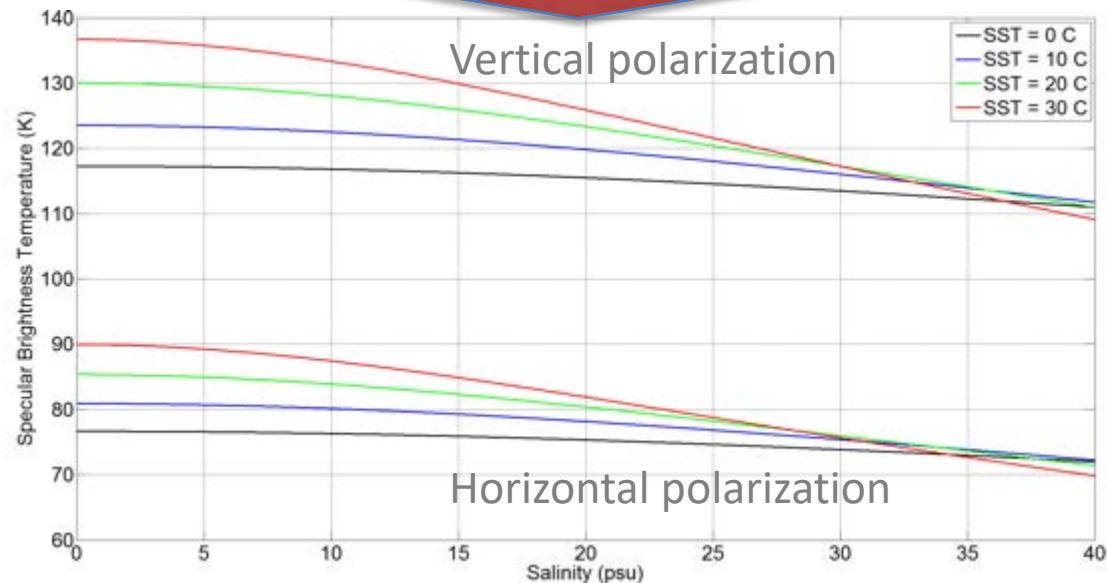


Salinity Science

- Satellite salinity instruments measure natural microwave emission from the top 1 cm (or less) of ocean surface in terms of *brightness temperature, TB*

Warmer water -> steeper curves -> better sensitivity of TB to salinity changes -> better signal to noise ratio -> more accurate salinity measurement

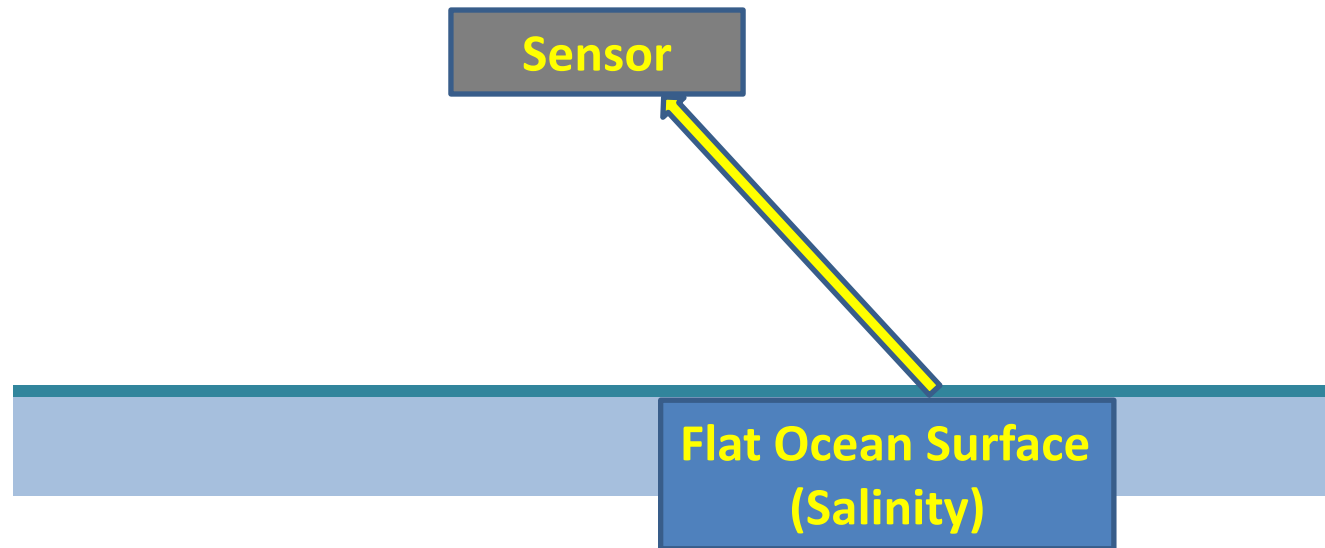
- TB is related to the dielectric properties of seawater



Meissner-Wentz Dielectric Model of sea water at 40° Earth Incidence Angle

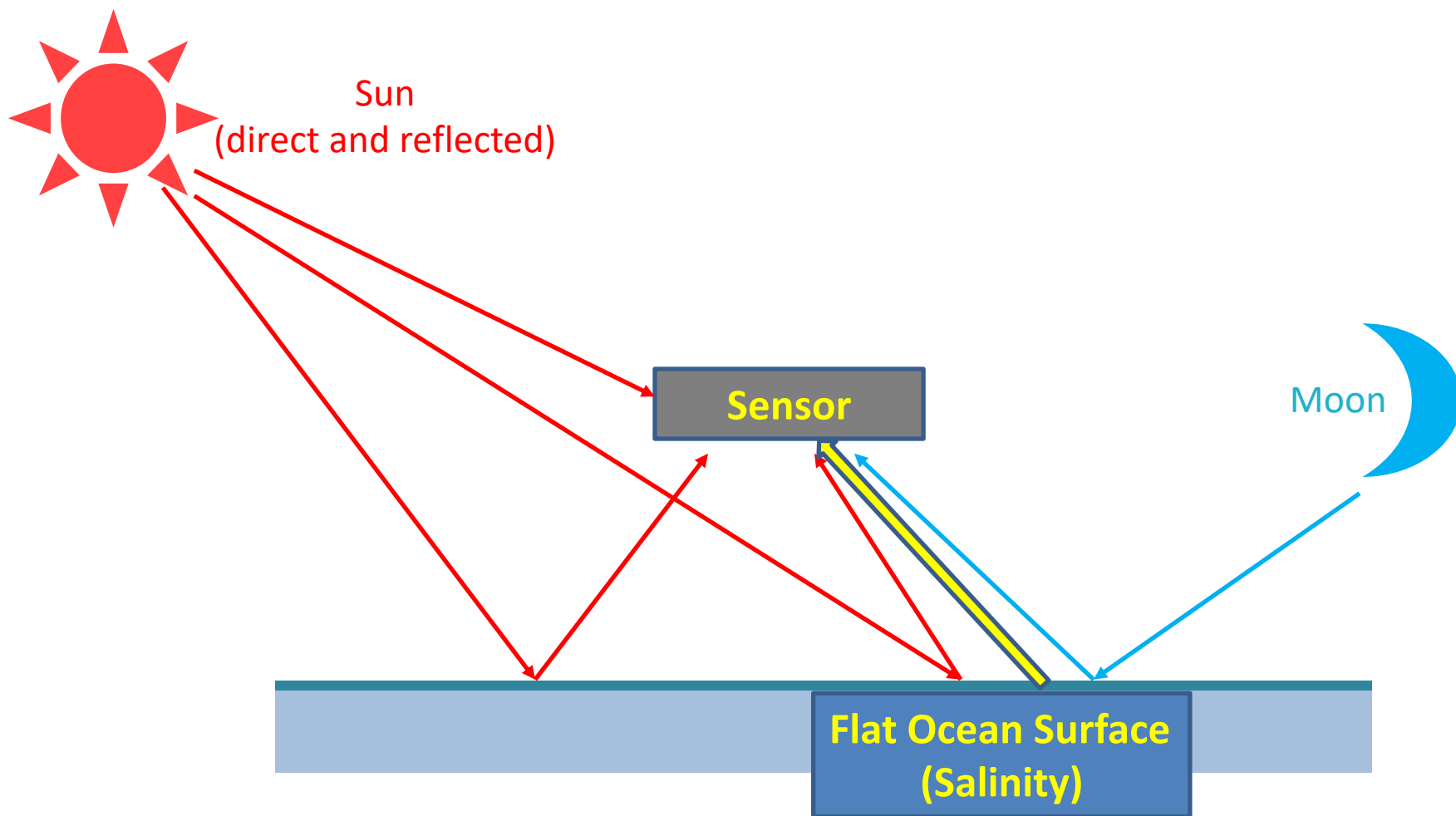


Salinity Retrieval by Satellite



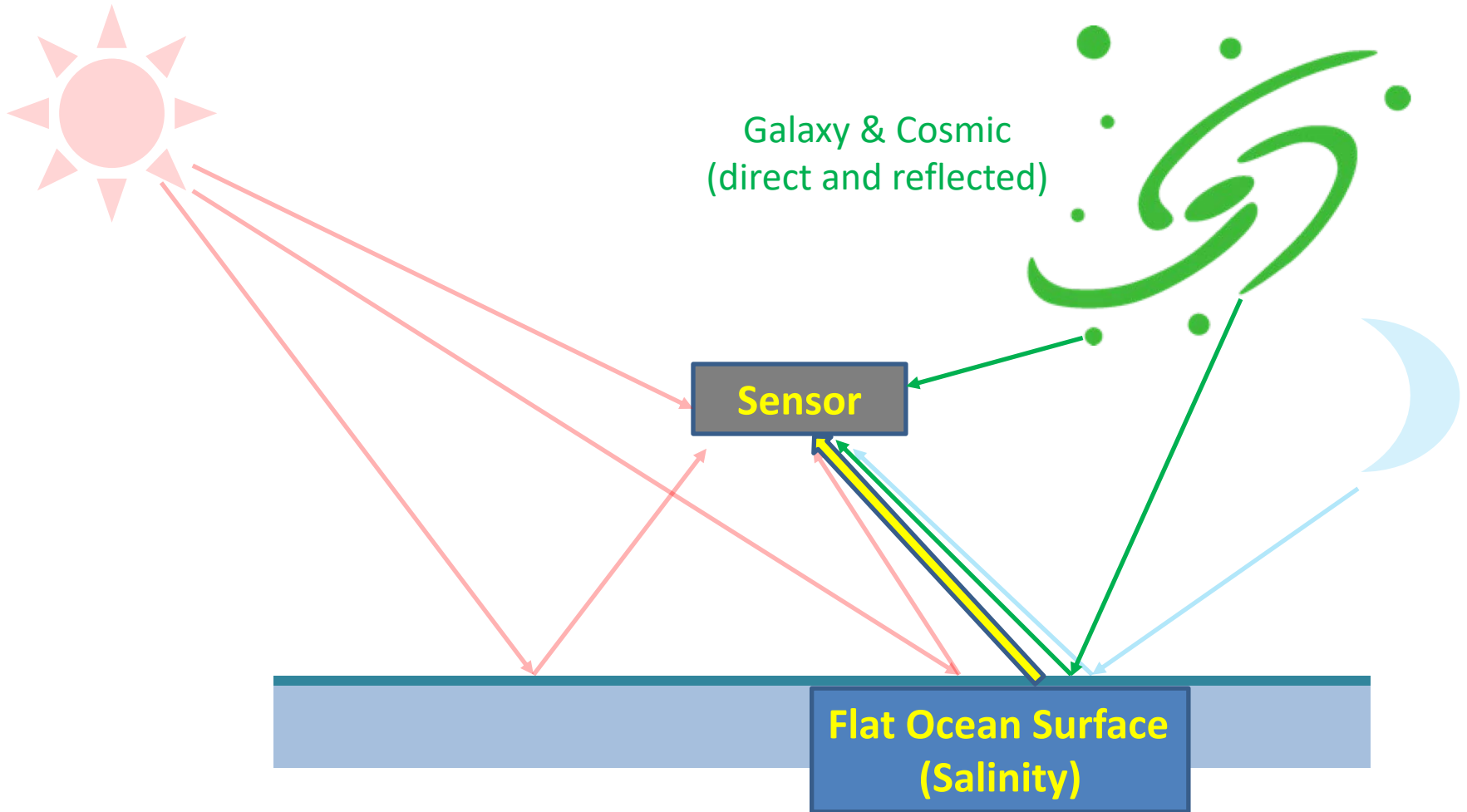


Salinity Retrieval by Satellite



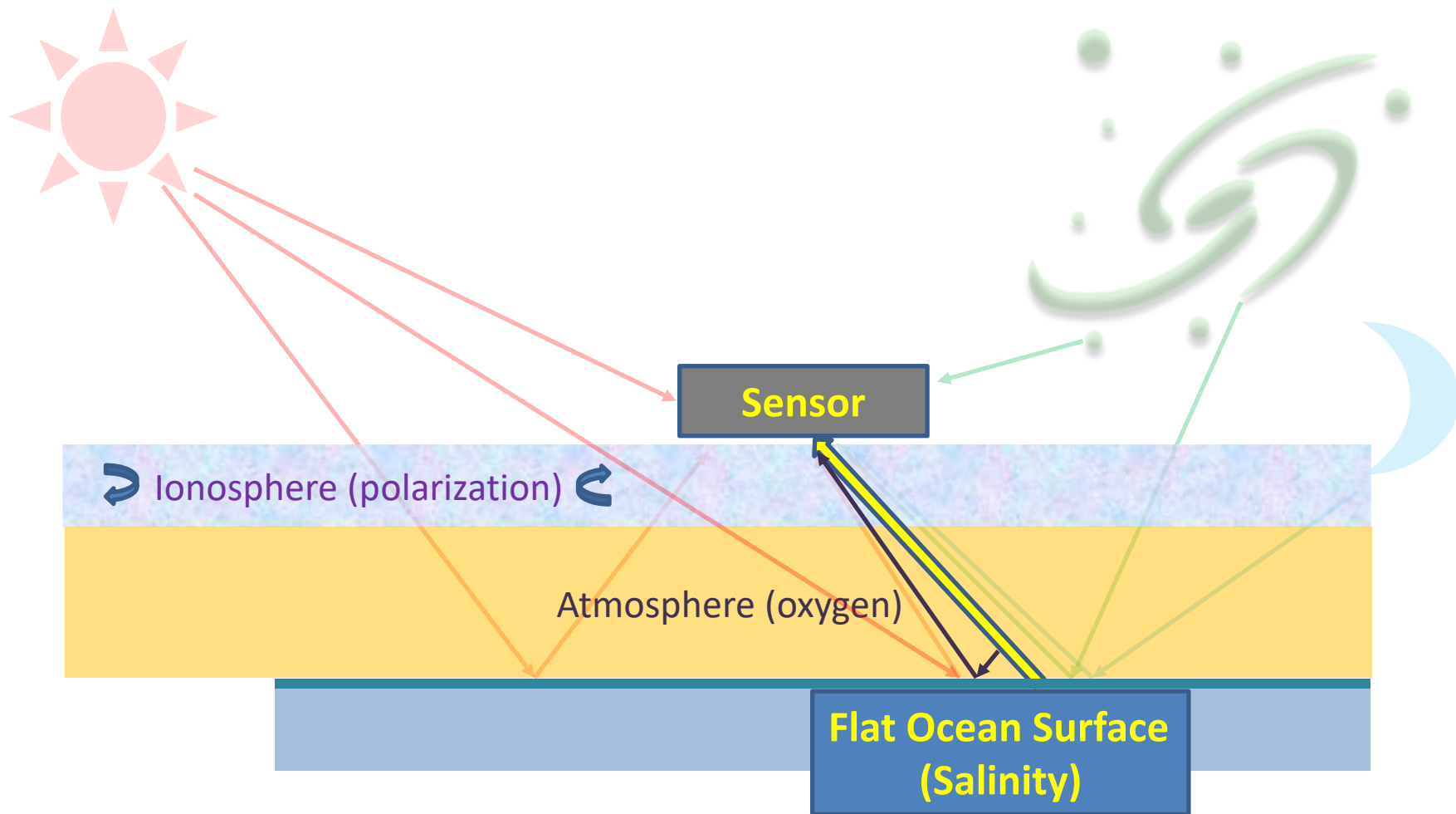


Salinity Retrieval by Satellite

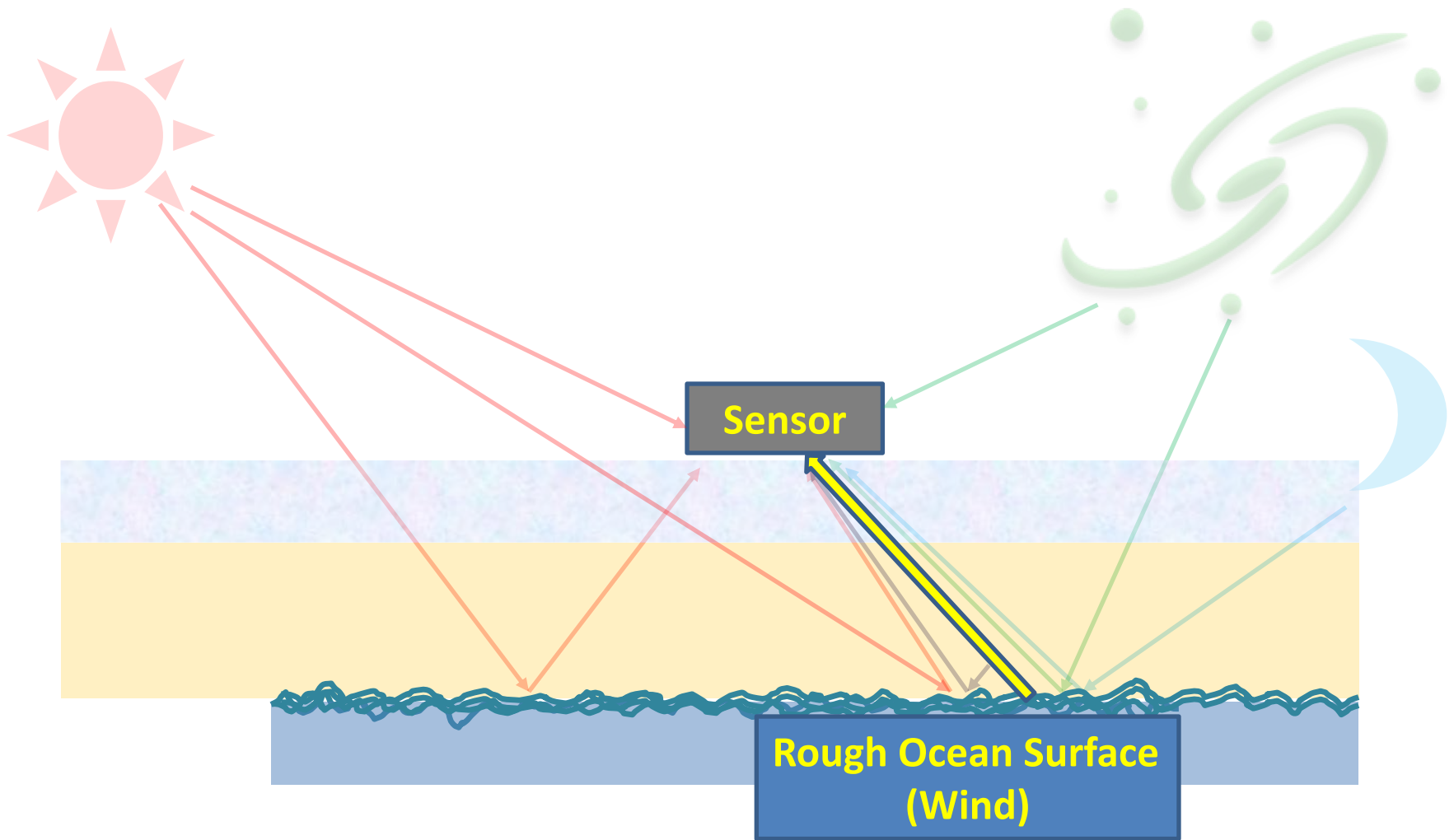




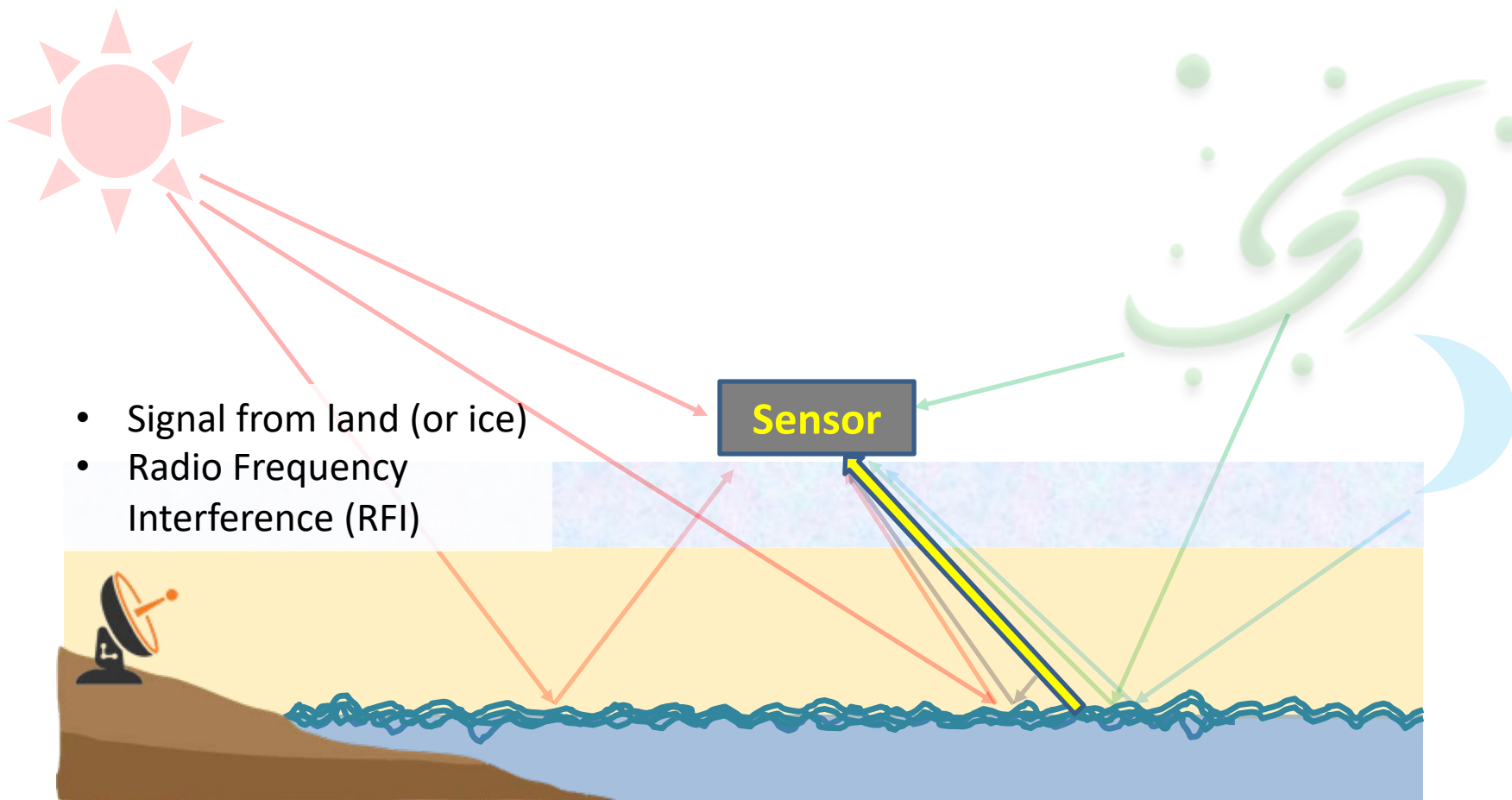
Salinity Retrieval by Satellite



Salinity Retrieval by Satellite



Salinity Retrieval by Satellite





Mission Design - Aquarius

- *Aquarius/SAC-D* was a U.S. – Argentina mission whose prime instrument measured salinity
 - Launched in June 2011
- Requirement for *Aquarius*:
 - *Monthly averaged sea surface salinity at 150 km spatial resolution with an accuracy of 0.2 (psu)*
- Full *Aquarius* data set (Version 5) is available
 - *Aquarius V5 achieved accuracy: 0.13 psu*

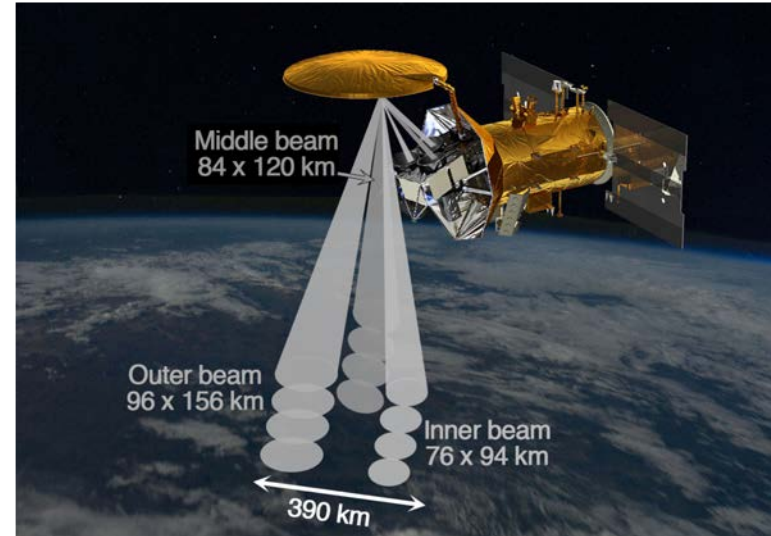
Mission Design - Aquarius

- *Aquarius* achieved its requirement through:
 - Instrument design
 - Extremely stable radiometers sensitive to changes in brightness temperature of about 0.1 K
 - Onboard scatterometer to measure ocean roughness
 - Orbit design
 - Sun avoidance
 - Global coverage
 - Repeat sampling



Mission Design - Aquarius

- *Aquarius* instrument design:
 - Non-emissive antenna (ideal)
 - 3 radiometers that measured brightness temperature at 1.41 GHz (“L-band”)
 - Two polarizations (Vertical, Horizontal)
 - Beams at various incidence angles (25.8° , 33.8° , 40.3°)
 - Full swath width of 390 km



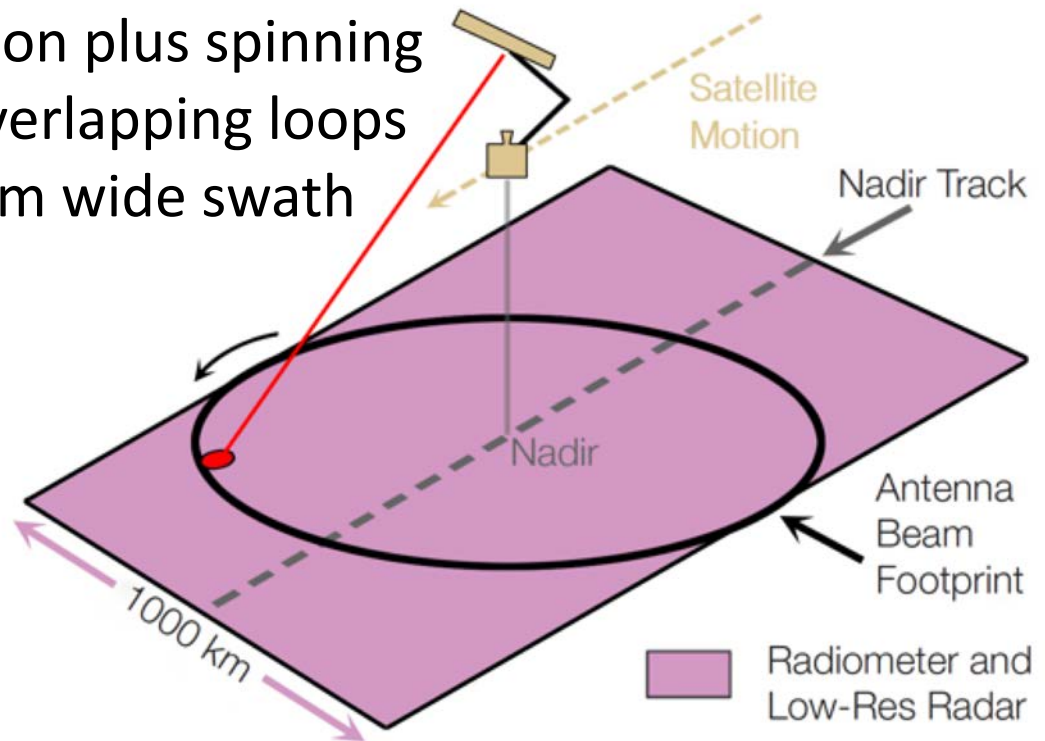
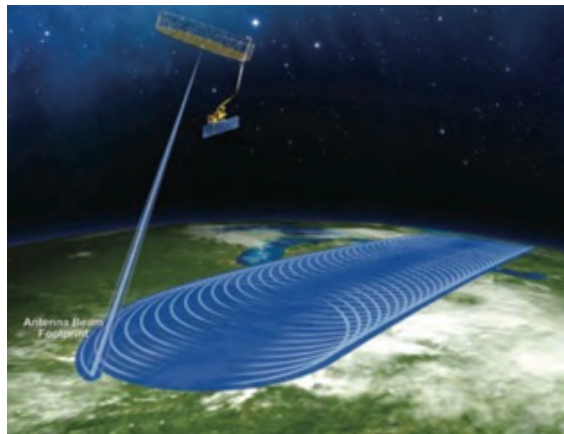
Mission Design - SMAP

- *Soil Moisture Active Passive (SMAP)* operates at L-band and is designed to measure soil moisture
 - Launched in January 2015
- Sea surface salinity retrieval
 - Same radiometer design as *Aquarius*
 - Antenna is 1% emissive
 - Creates erroneous signals when the antenna goes in/out of solar eclipse, due to very large changes in the physical temperature of the antenna



Mission Design - SMAP

- *SMAP* instrument characteristics:
 - Antenna spins at 14.9 rpm (one revolution every 4 sec)
 - Satellite orbital motion plus spinning footprint result in overlapping loops that create a 1000-km wide swath





	Aquarius	SMAP
Orbit altitude	657 km (408 mi)	685 km (426 mi)
Orbit repeat time	7 days	8 days
Ascending node	6 PM local	6 PM local
Antenna diameter	2.5 m (8.2 ft)	6 m (19.7 ft)
Antenna type	Stationary; 100% reflective	Spinning; 99% reflective (1% emissive)
Radiometer(s)	3 (25.8°, 33.8°, 40.3°)	1
Swath width	350 km (218 mi)	1000 km (621 mi)
Global coverage	7 days	3 days
Footprint size*	150 x 150 km (93 x 93 mi)	39 x 47 km (24 x 29 mi)
Operation period	25-Aug-2011 to 07-Jun-2015	01-Apr-2015 to present
Radar / Wind correction	Scatterometer (1.26 GHz); Internal wind correction provided	High-res radar failed 07-Jul-15; External wind correction needed

**Note that SMAP's footprint size is smaller than that of Aquarius, thus it has better spatial resolution (~40 km). However, SMAP's 40-km product is much noisier than Aquarius. As a result, some SMAP products are spatially averaged to larger footprints (i.e., 60 km, 70 km) to reduce data noise.*



SMAP Data Products

- SMAP salinity data are processed by:
 - Remote Sensing Systems (RSS)
 - Jet Propulsion Laboratory (JPL)
- Data are available from PO.DAAC
 - Orbital/Swath (Level 2)
 - Gridded (Level 3)
 - 8-day running mean
 - Monthly
 - Sampling at three resolutions:
 - ~40 km and 70 km (RSS)
 - 60 km (JPL)