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An unprecedented era of satellite measured wind and wave data – opportunities for Australia

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Oceanographic satellites

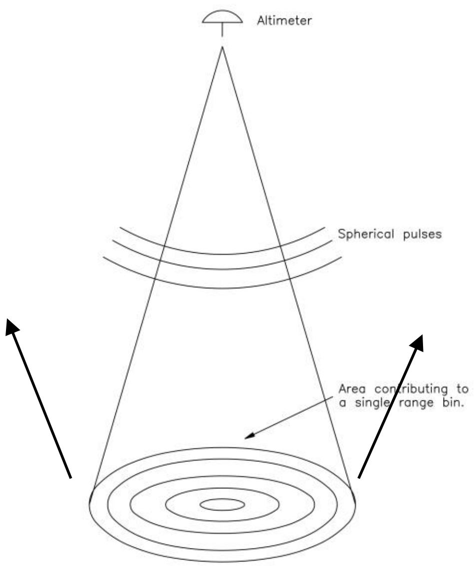
Satellite systems:

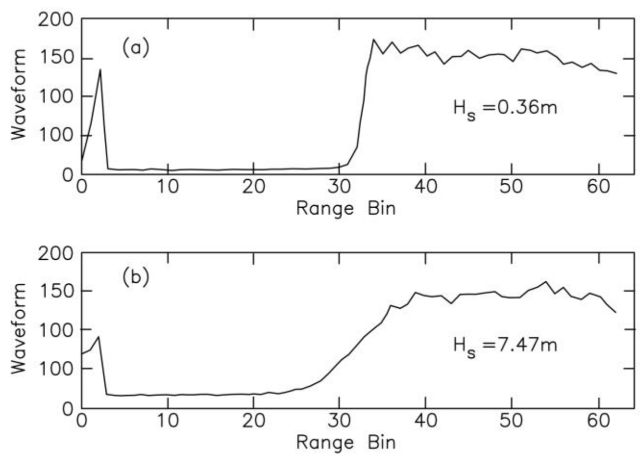
- Altimeters – wave height, wind speed, *sea level*
- Radiometers – wind speed
- Scatterometers – wind speed and direction
- Synthetic Aperture Radar – wave spectrum, wind speed

- What they actually measure
- Data availability
- Data limitations
- The next generation
- Why an advantage for Australia

Altimeter

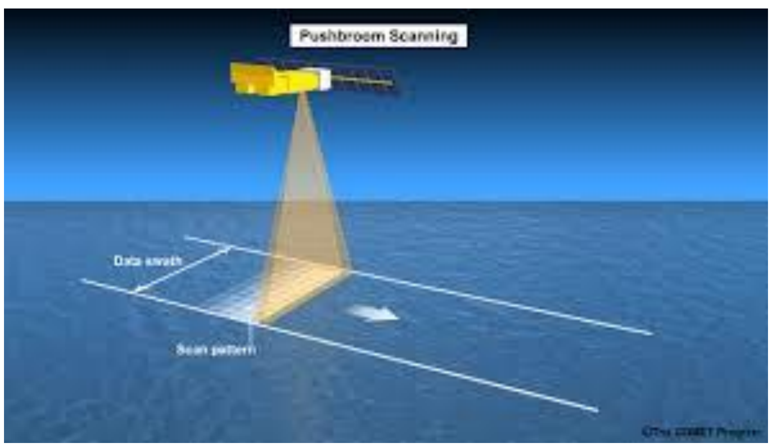
- Nadar looking
- Significant wave height – leading edge of return pulse
- Wind speed – radar cross-section – related to MSS

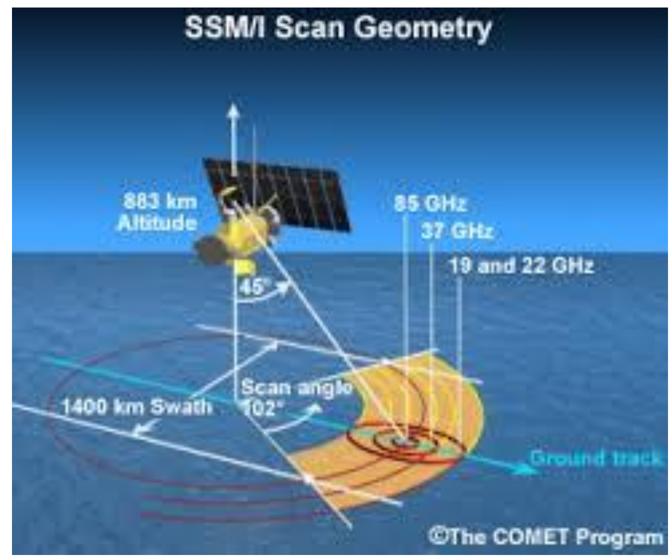




Radiometers

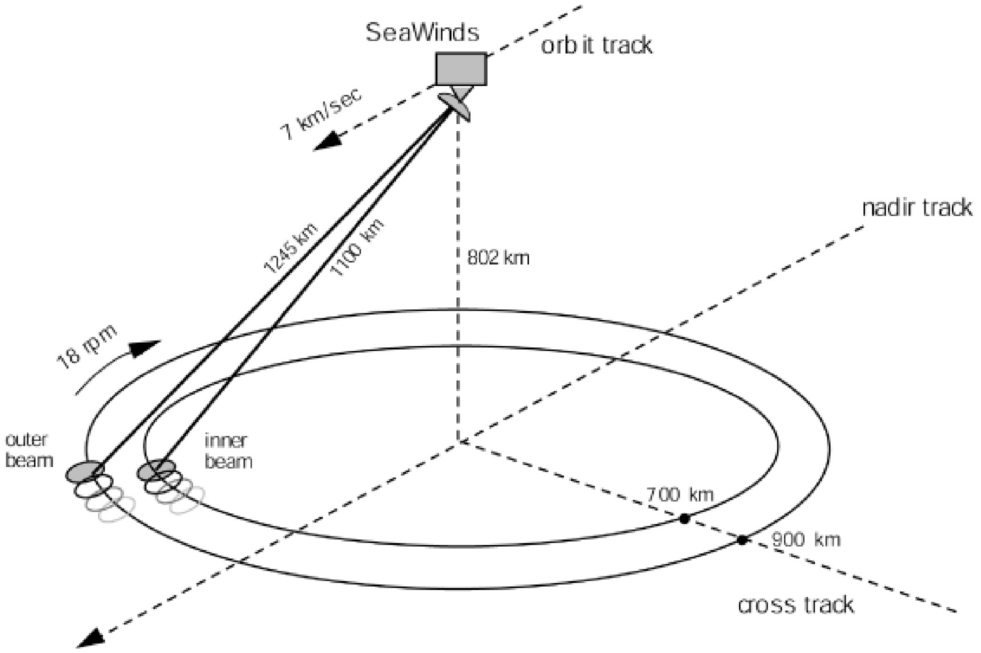
- Passive instruments – measure brightness temperature (radiance) – related to dissipation of waves and hence wind speed
- Measure over a broad swath





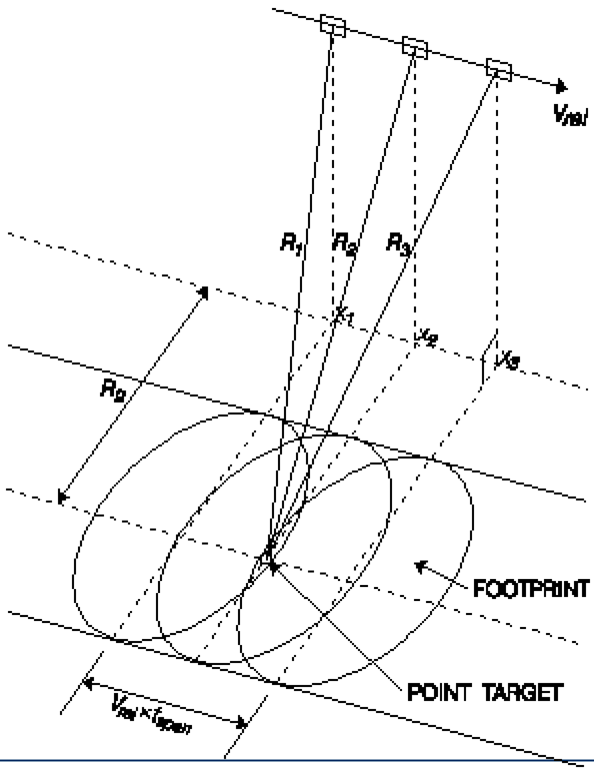
Scatterometer

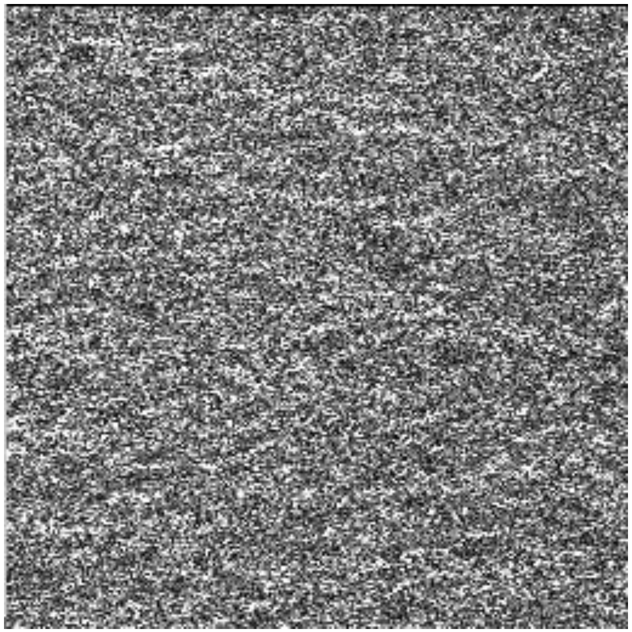
- Active microwave instrument – radar cross-section from multiple angles to give wind speed and direction



Synthetic Aperture Radar

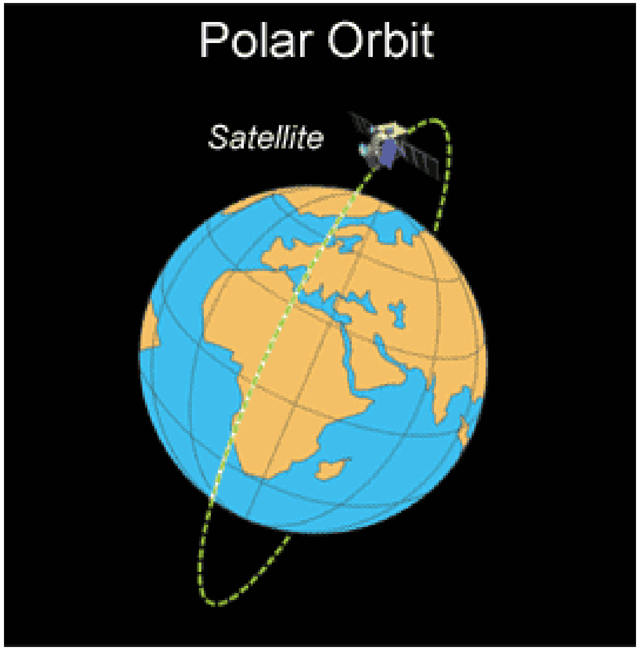
- Forward motion of Satellite creates a Synthetic Aperture – high resolution but Doppler smearing
- Measures modulation of Bragg scatters

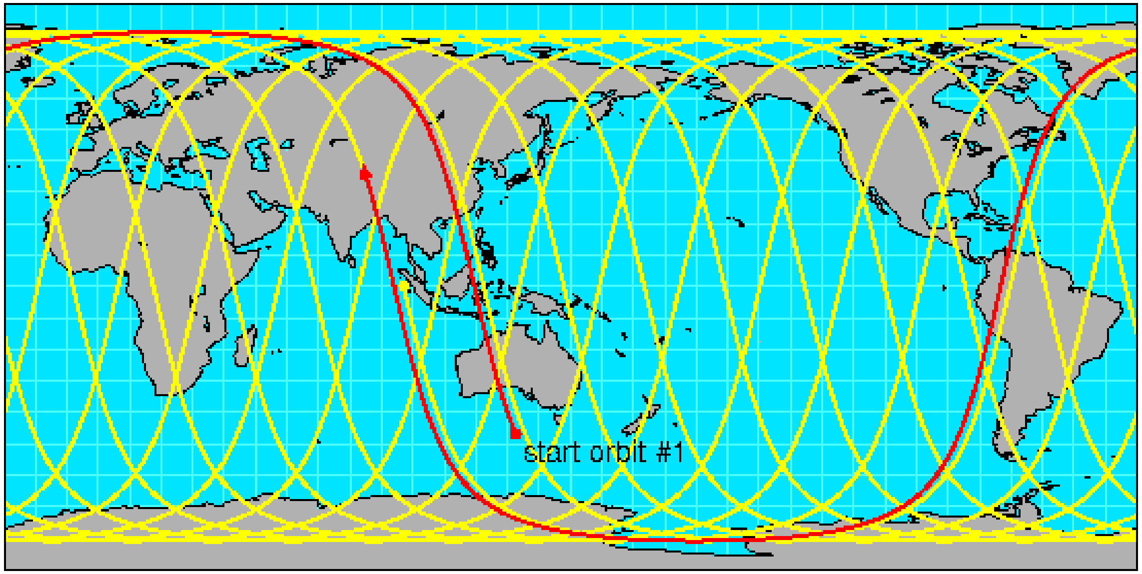




Satellite orbit and ground track

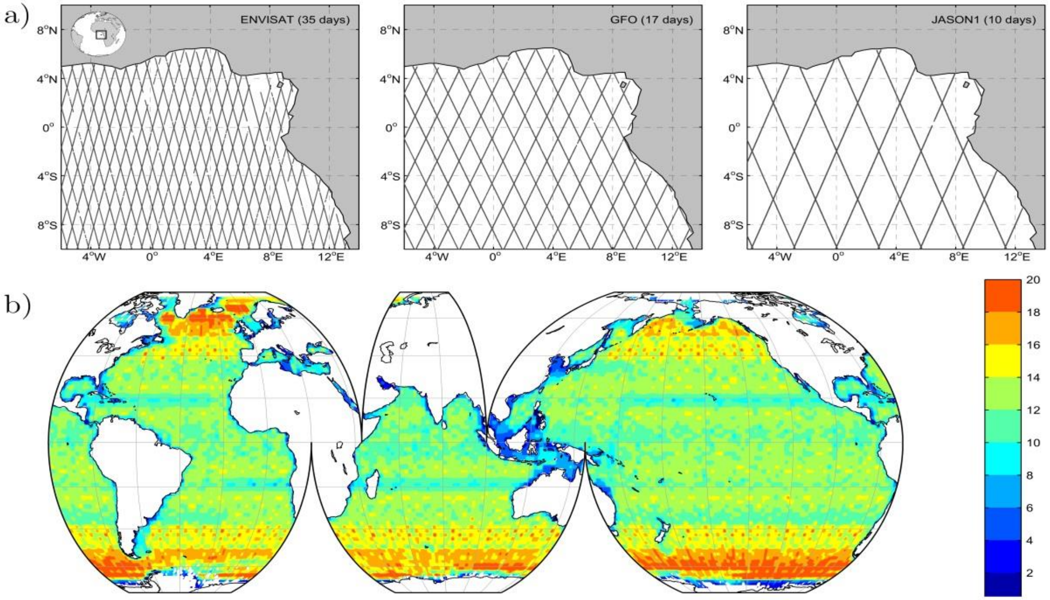
- Most oceanographic satellites are in near-polar orbits



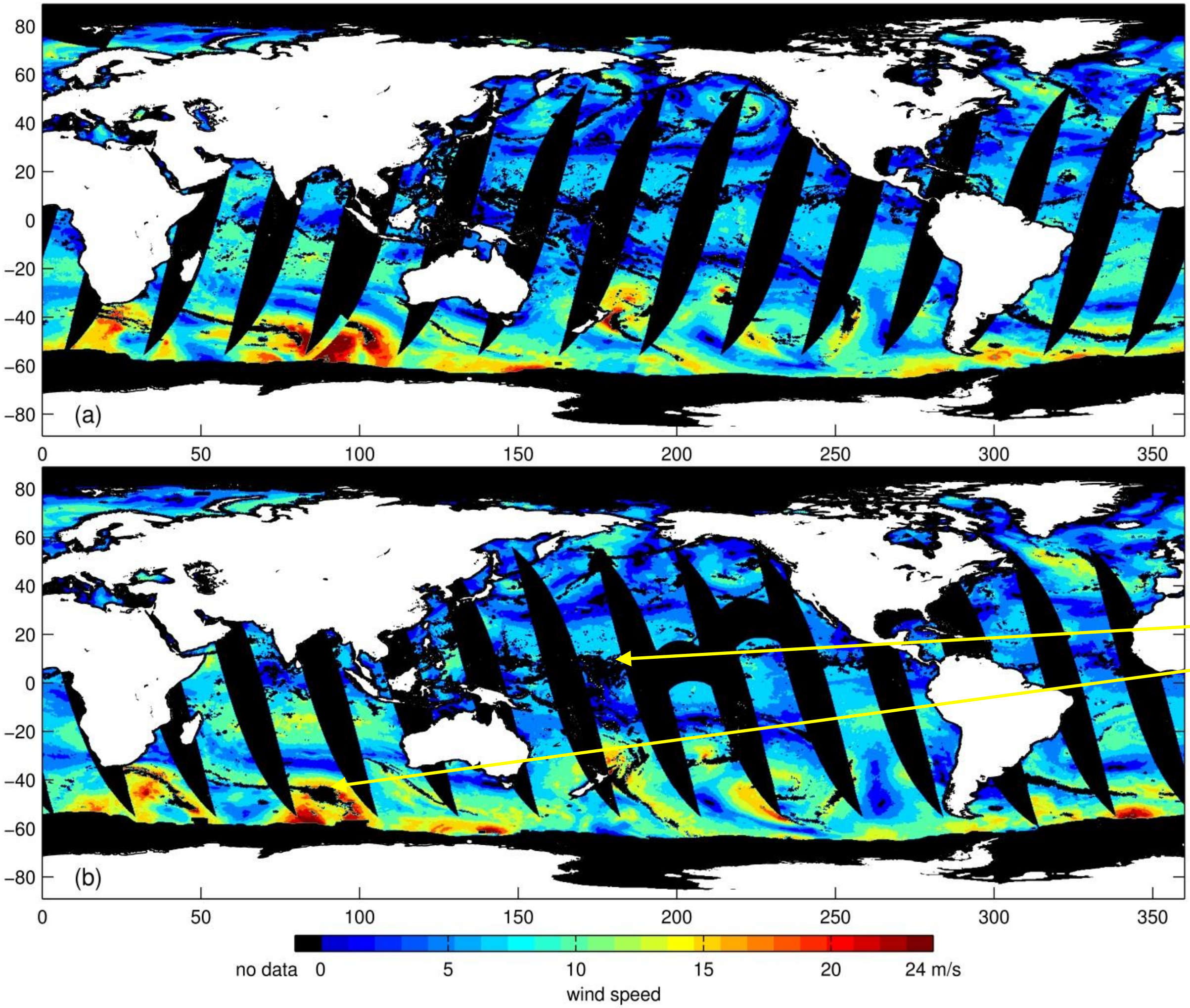


Satellite Data Coverage – Altimeter

- ERM typically 10 days
- 300km to 500km ground track separation



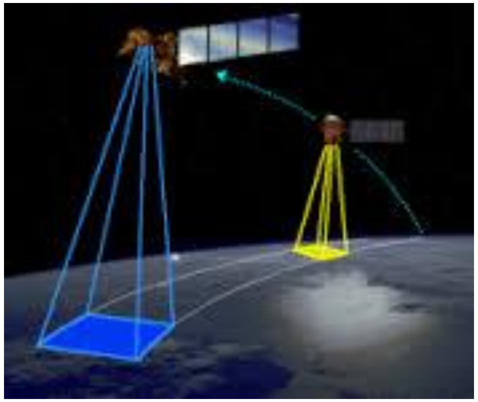
Satellite Data Coverage – Radiometer/Scatterometer



Data “holes” under rain

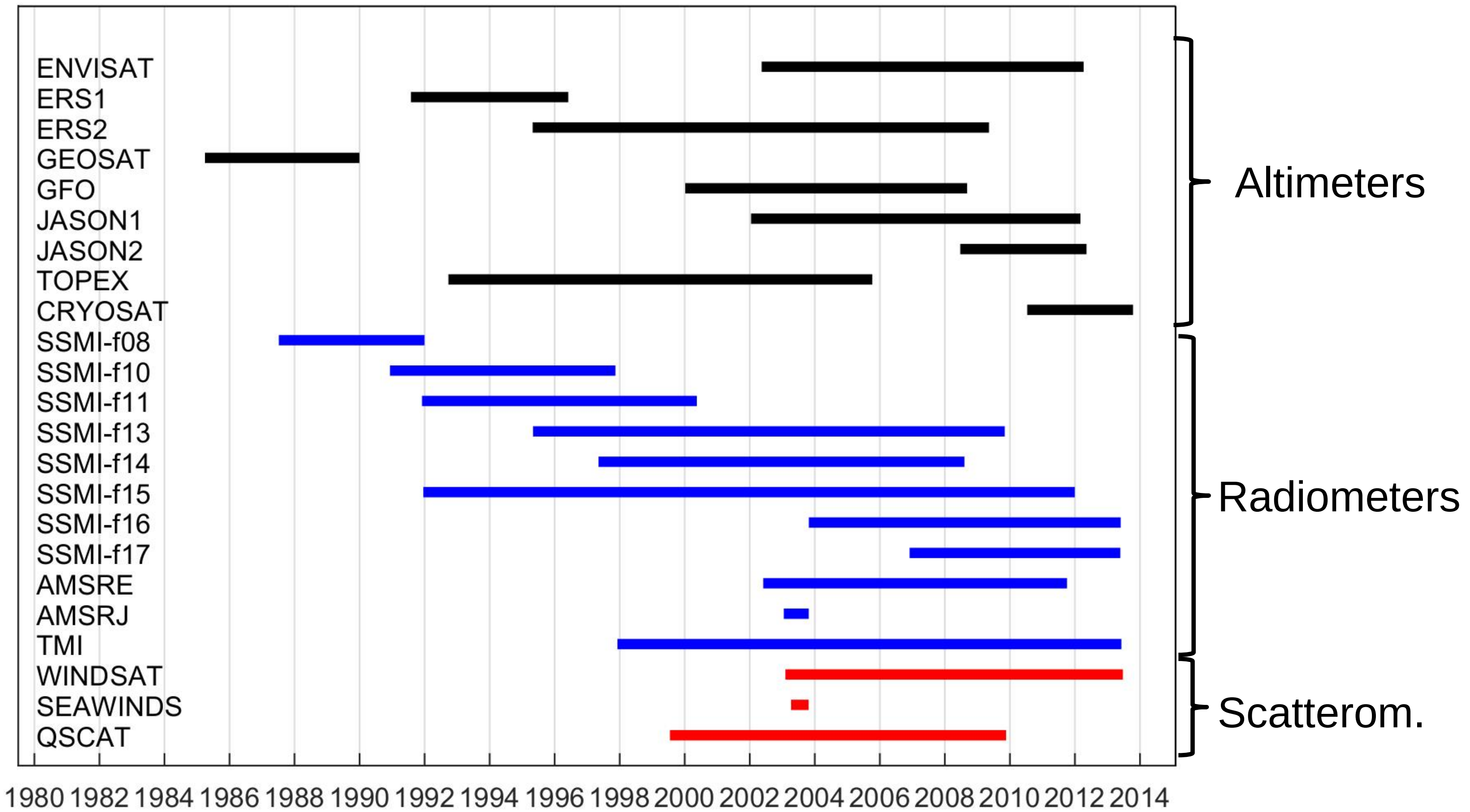
Advantages and disadvantages of satellite data

Advantages	Disadvantages
True global coverage	Footprint appox. 10km
30 year data record	Altimeter repeat sampling
Wave height and wind speed	Radiometer fair weather bias
	Questions about high wind speeds
	Issues around relationship between wind and sensed quantity
	Multiple sources, multiple formats

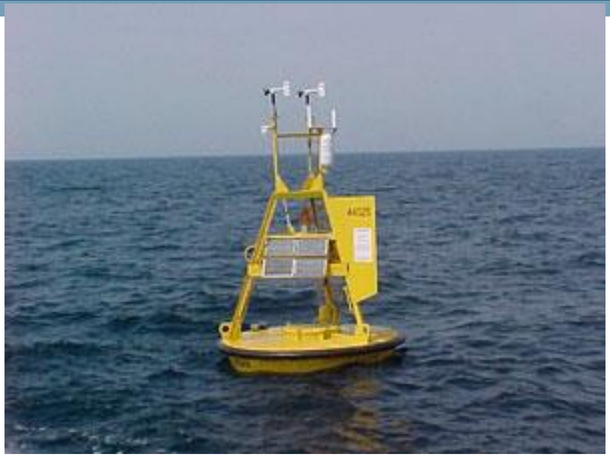


Building a consistent data base

Combined dataset of 30 years duration

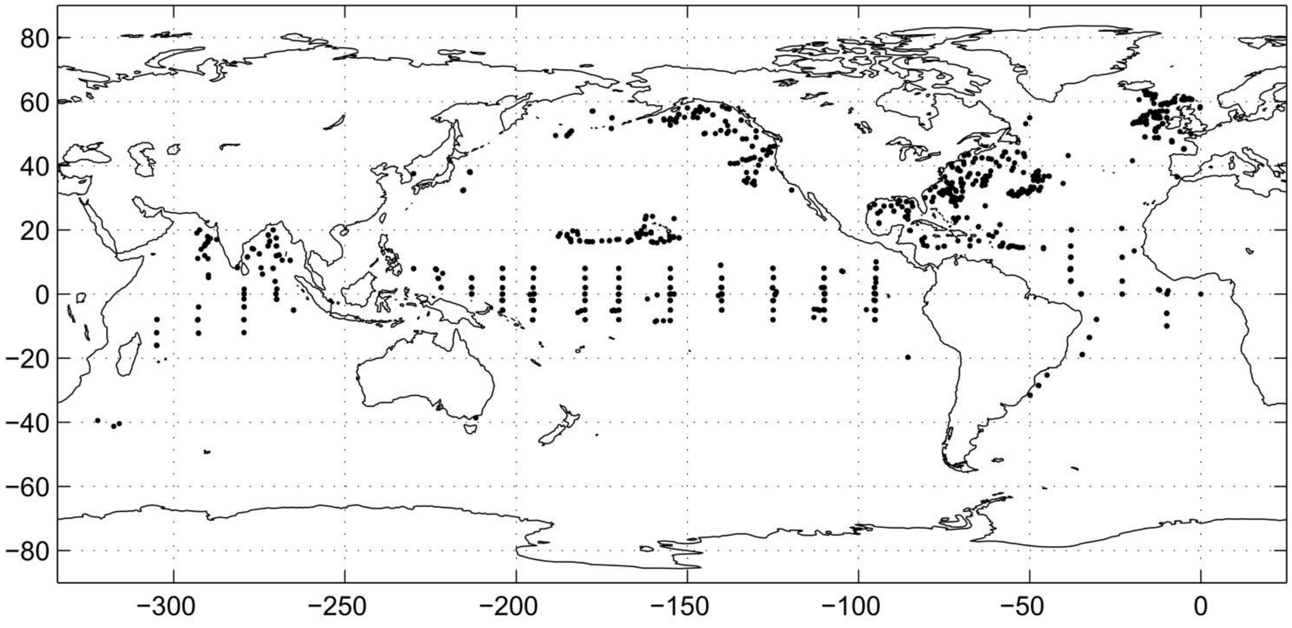


Insitu calibration buoys



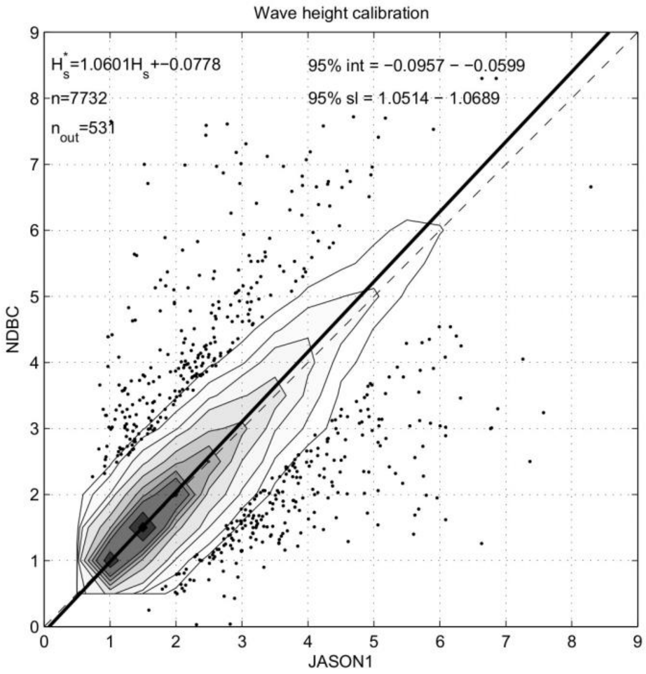
Two data sets

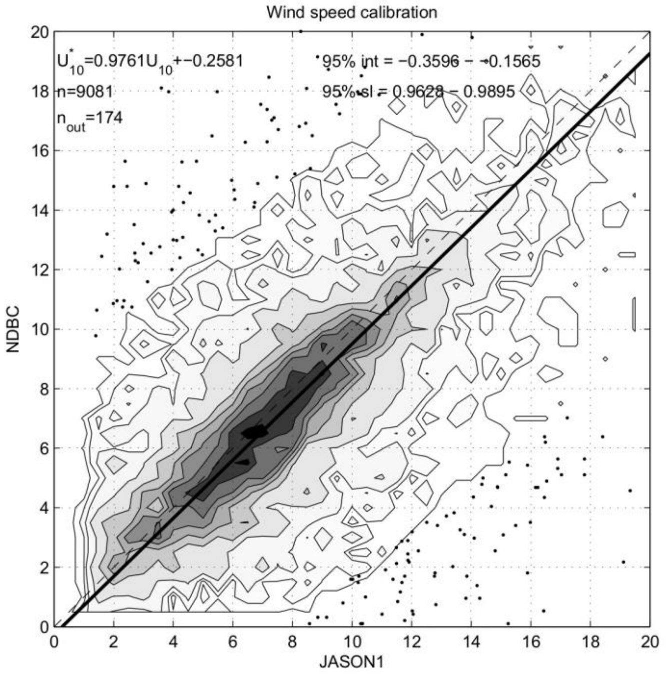
- NDBC
- ECMWF composite data



Altimeter calibration

Matchups – 50km and 30 mins.

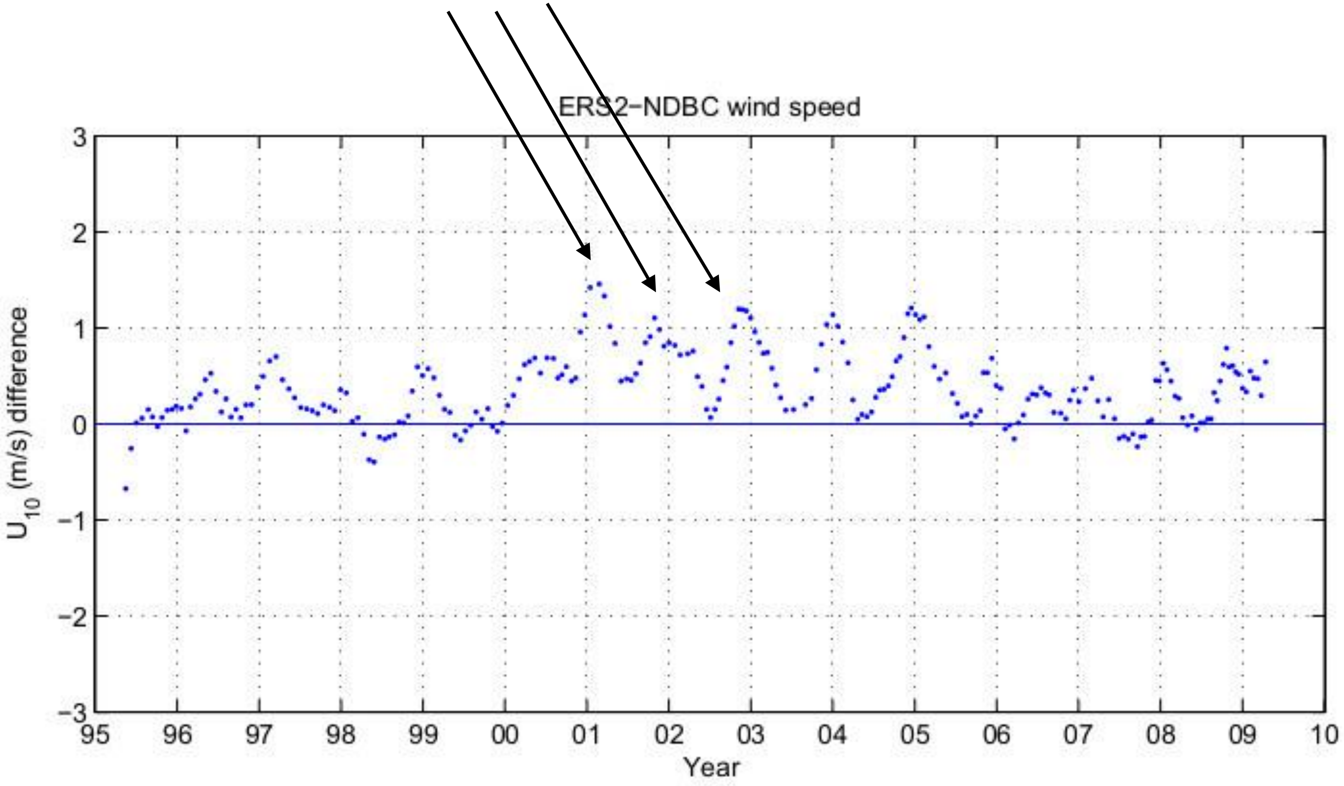




Greater scatter for wind speed

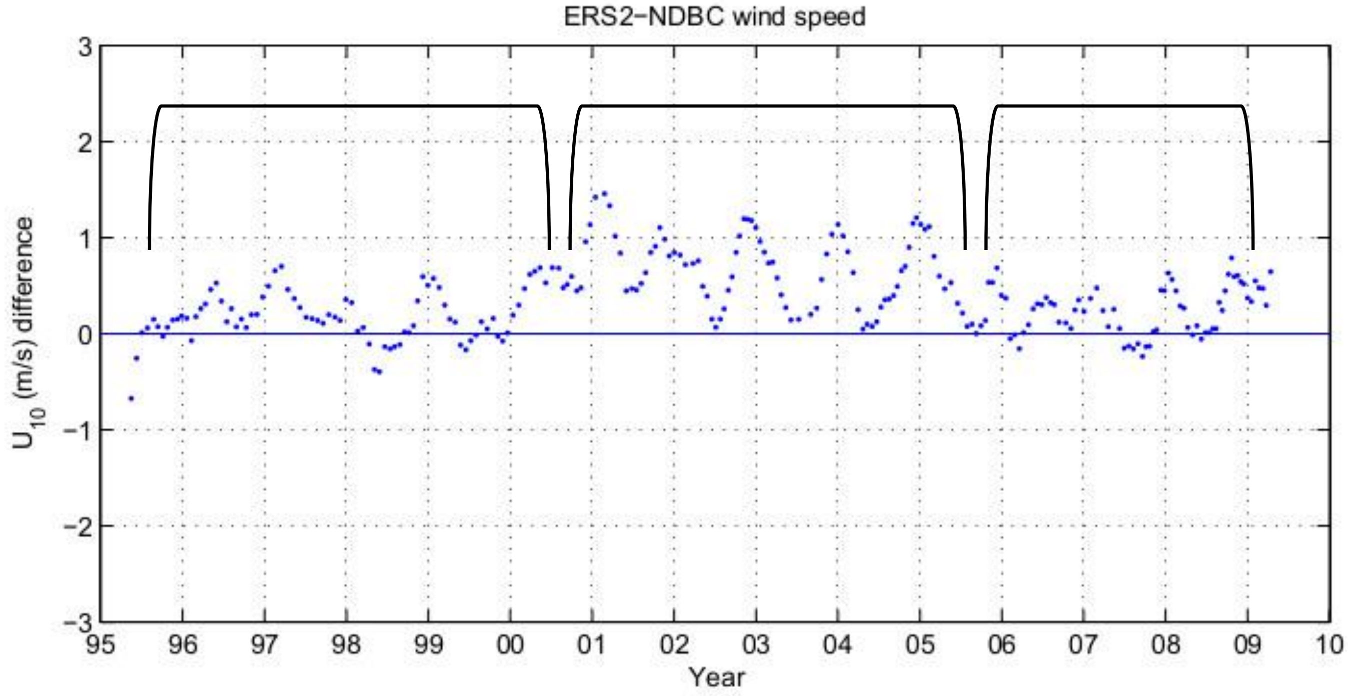
Altimeter long term stability

Annual cycle as NDBC buoys in Northern Hemisphere
Most likely due to changes in atmospheric stability



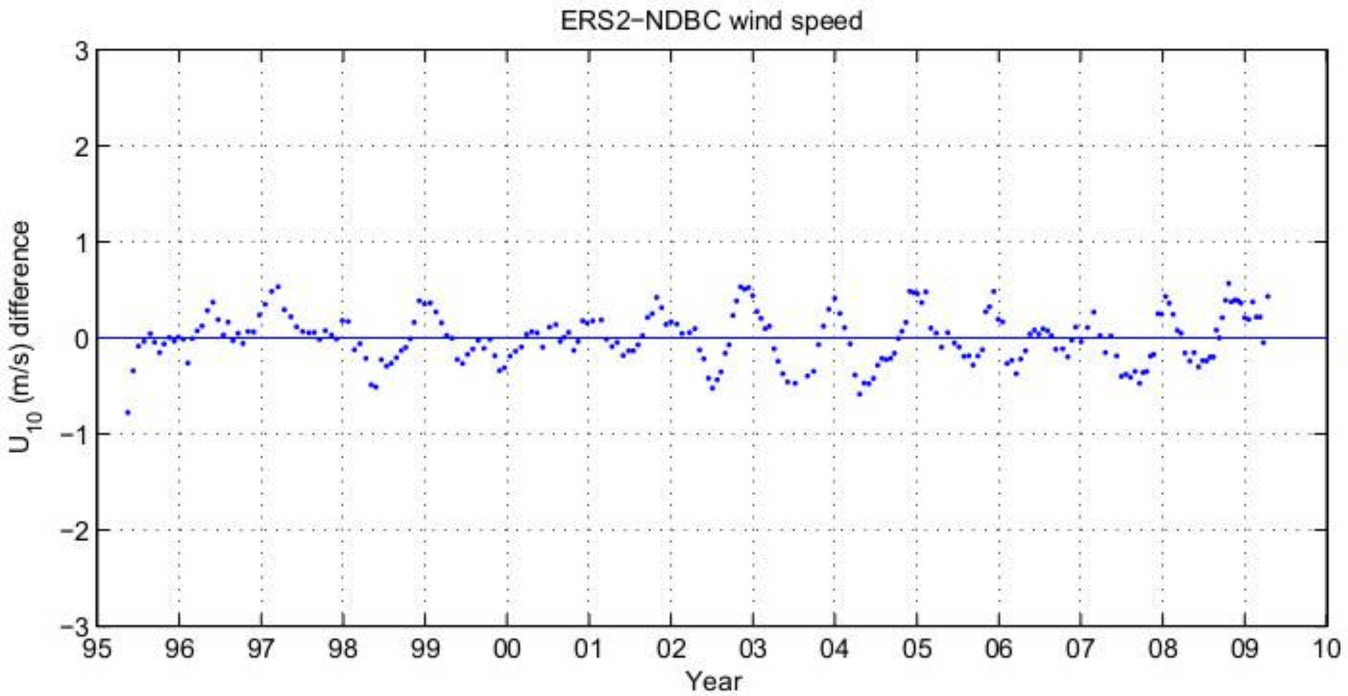
Altimeter long term stability

Apparent discontinuities in time
Piecewise calibration for each section separately



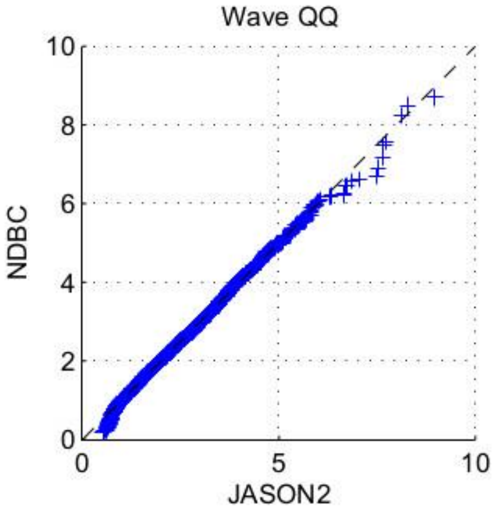
Altimeter long term stability

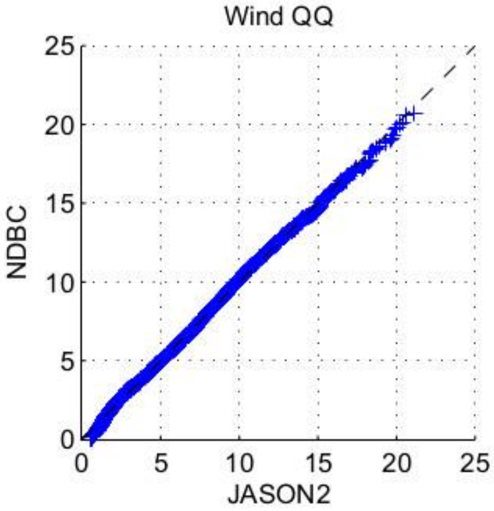
Discontinuities removed



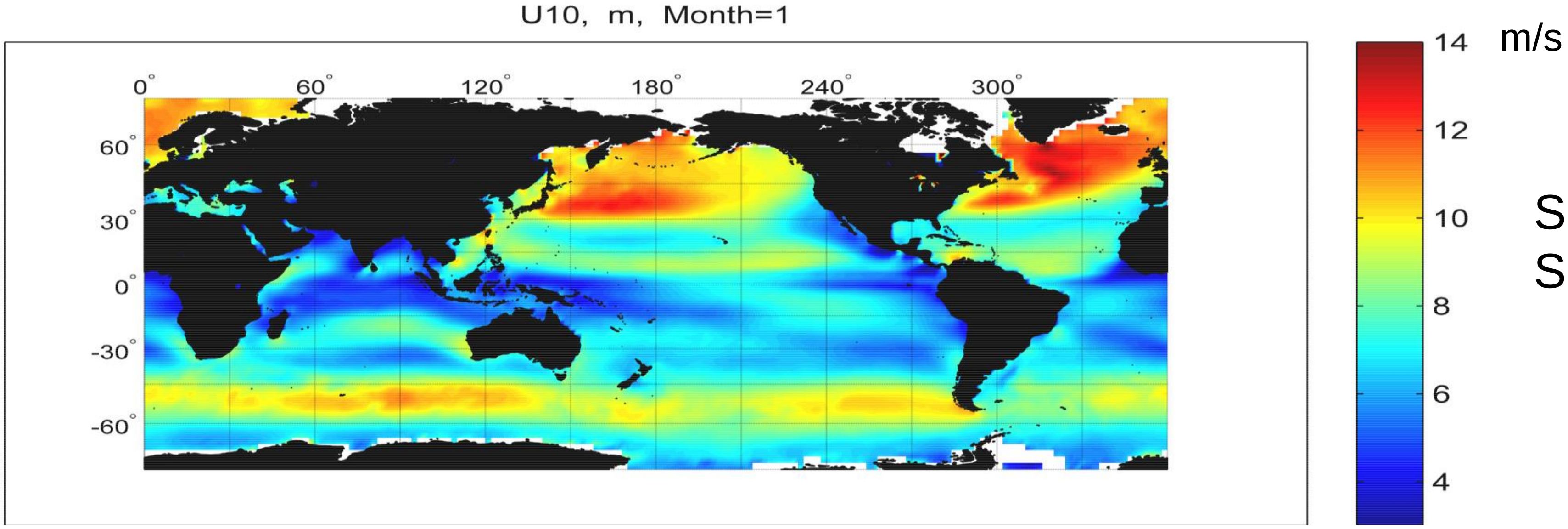
Buoy – altimeter PDF comparisons

- Altimeter wind speed and wave height both reproduce PDF of buoy data

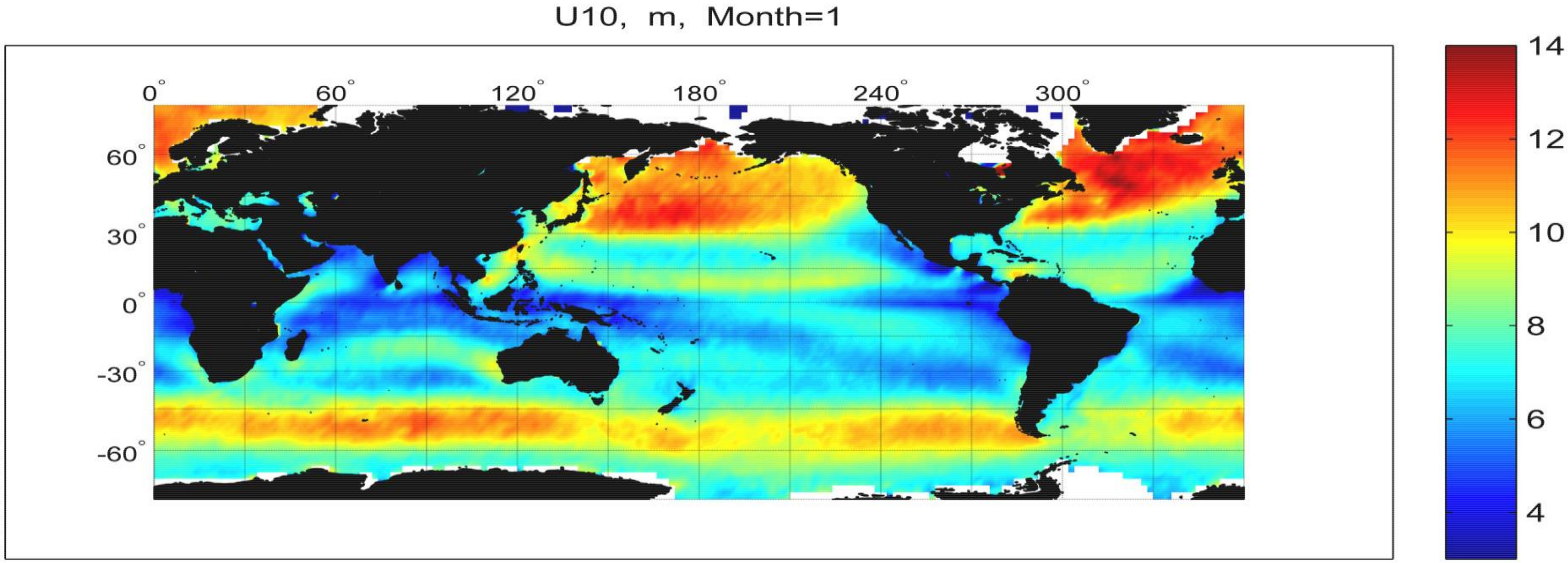




Global climatology – January U_{10} Monthly means

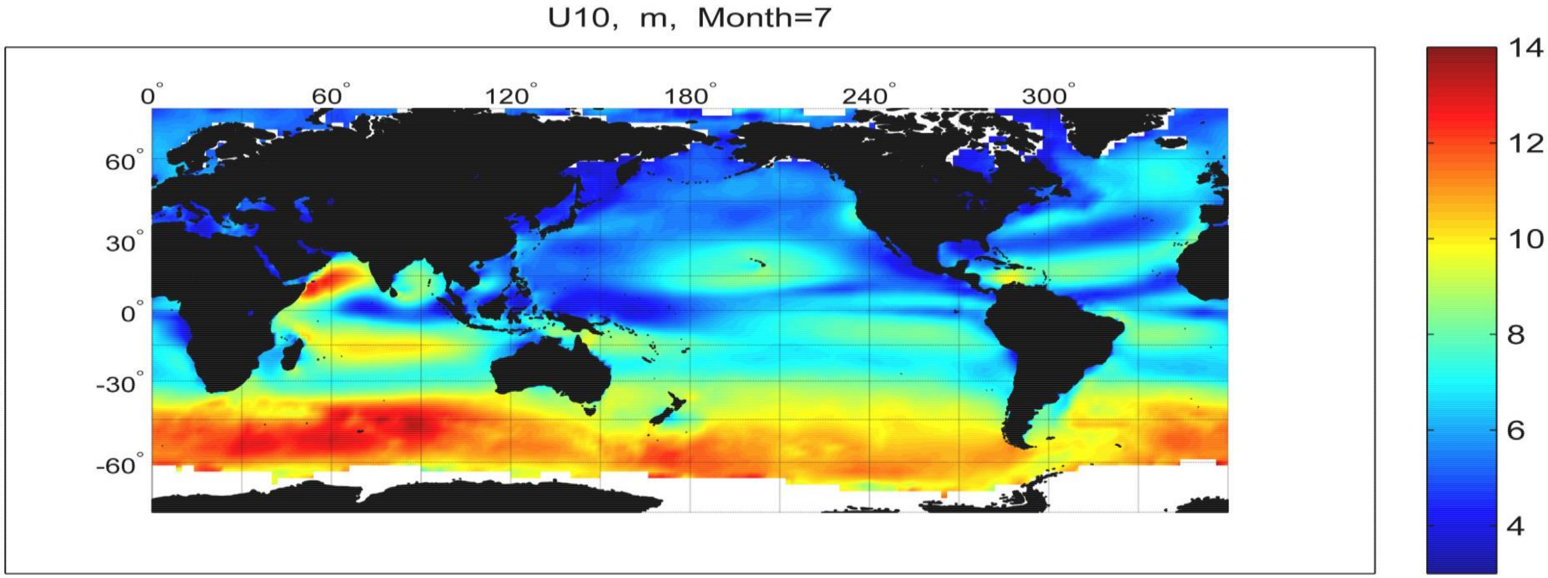


SSMI/ Scat



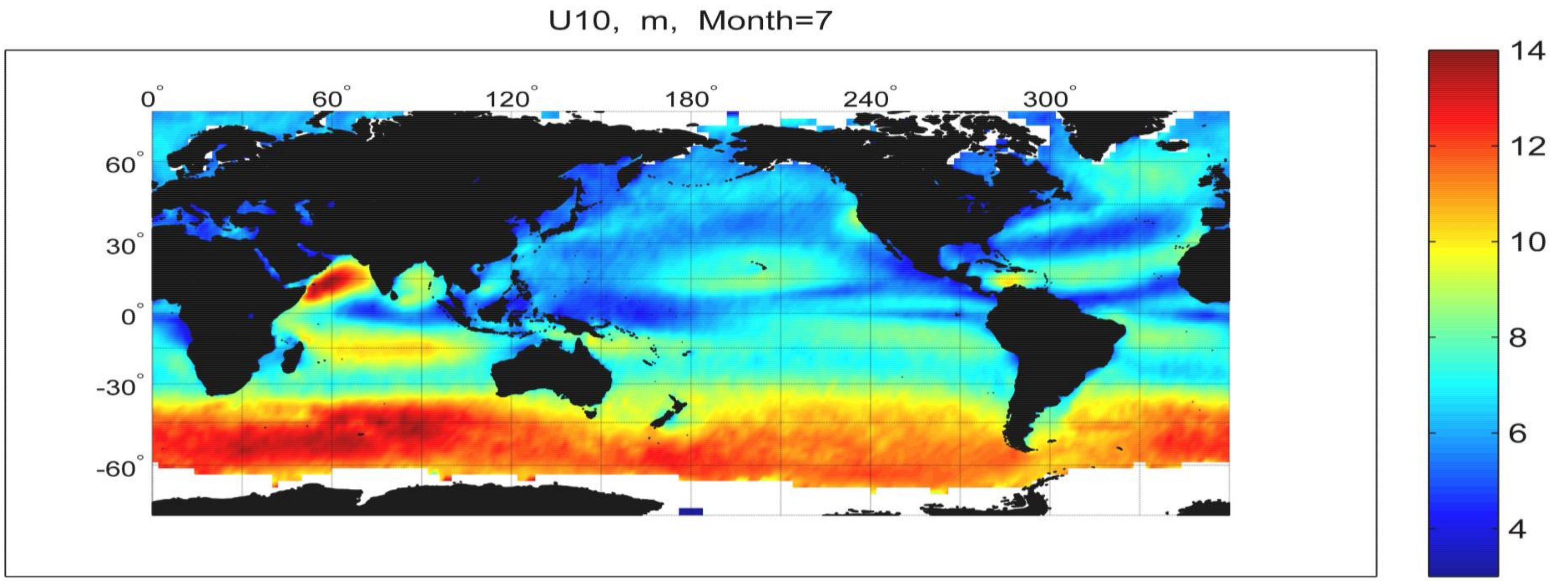
Altimeter

Global climatology – July U_{10} Monthly means



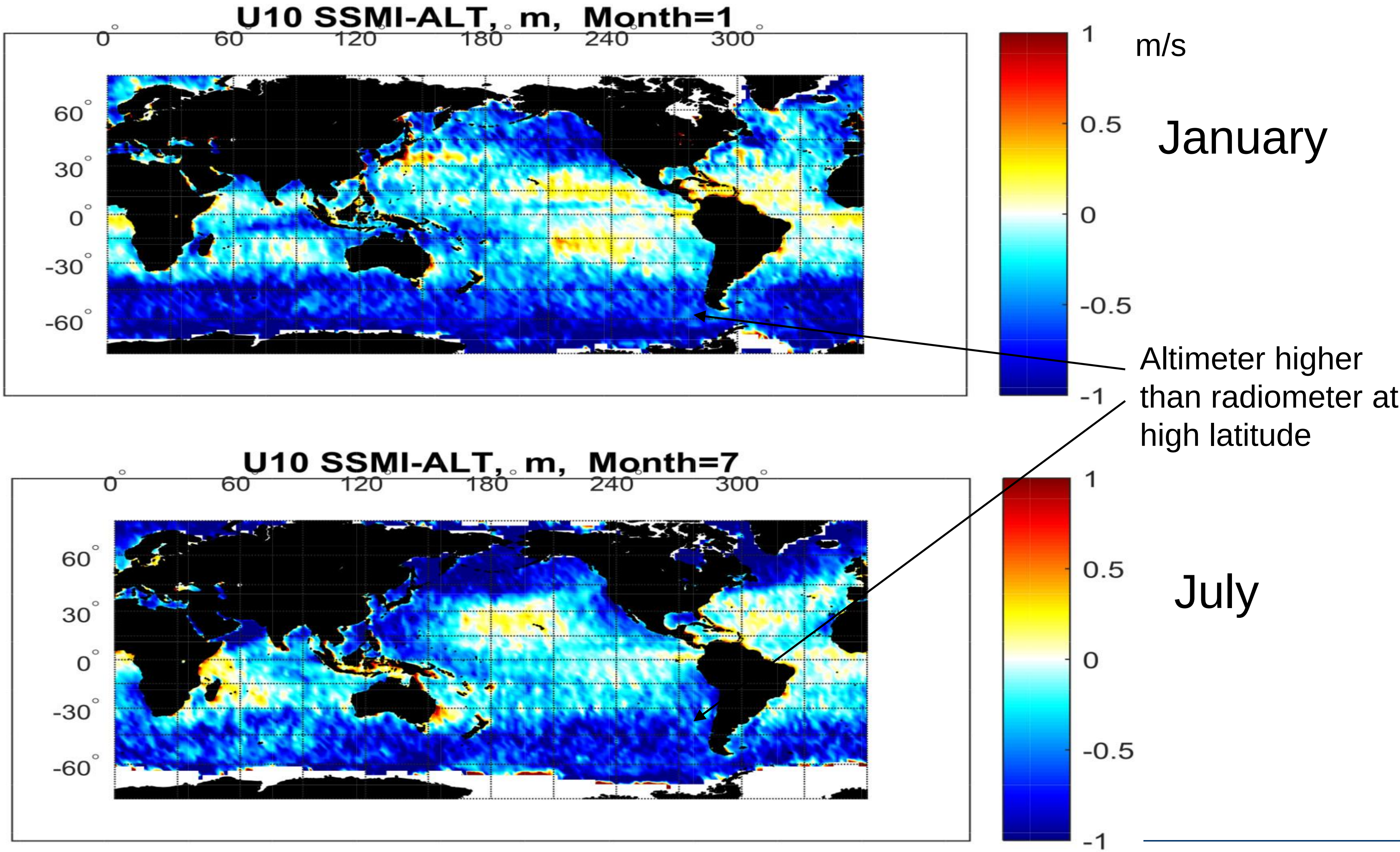
m/s

SSMI/
Scat



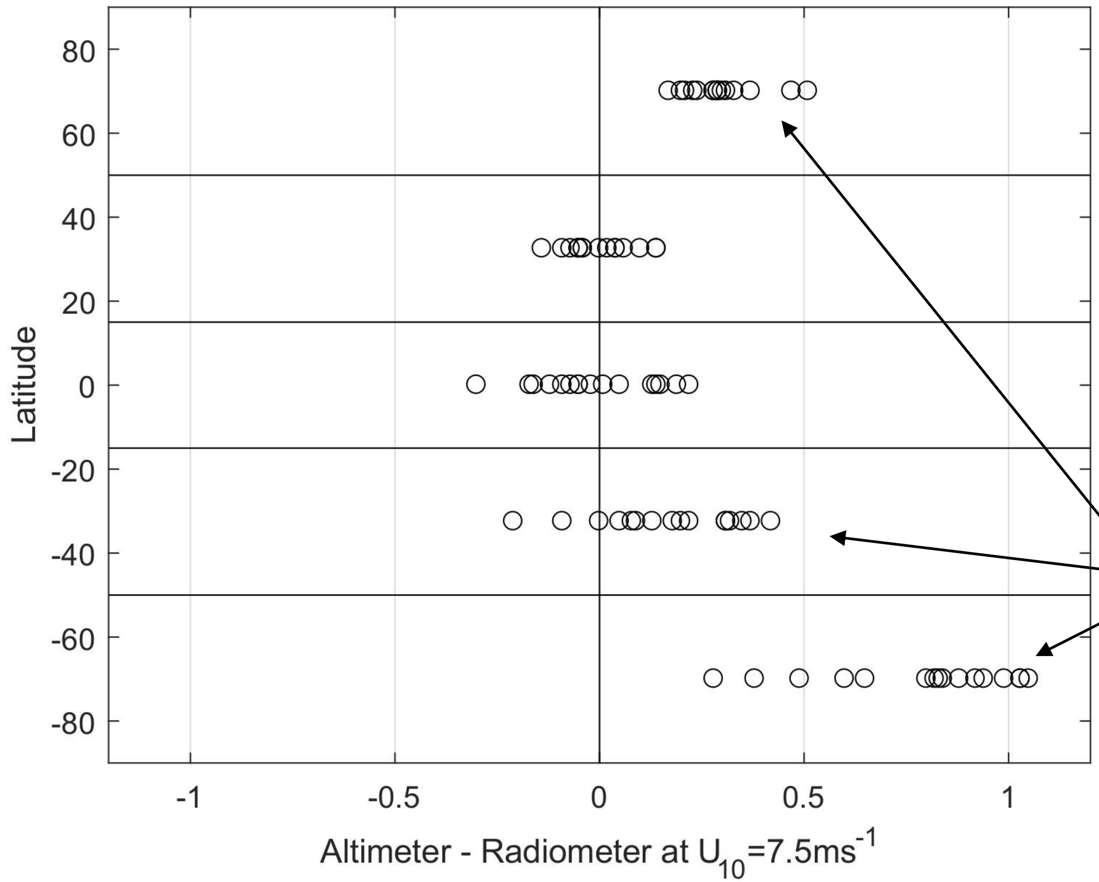
Altimeter

Difference in Monthly Mean – U_{10}



Difference in validation at $U_{10} = 7.5ms^{-1}$

Altimeter – Radiometer matchups – difference with latitude



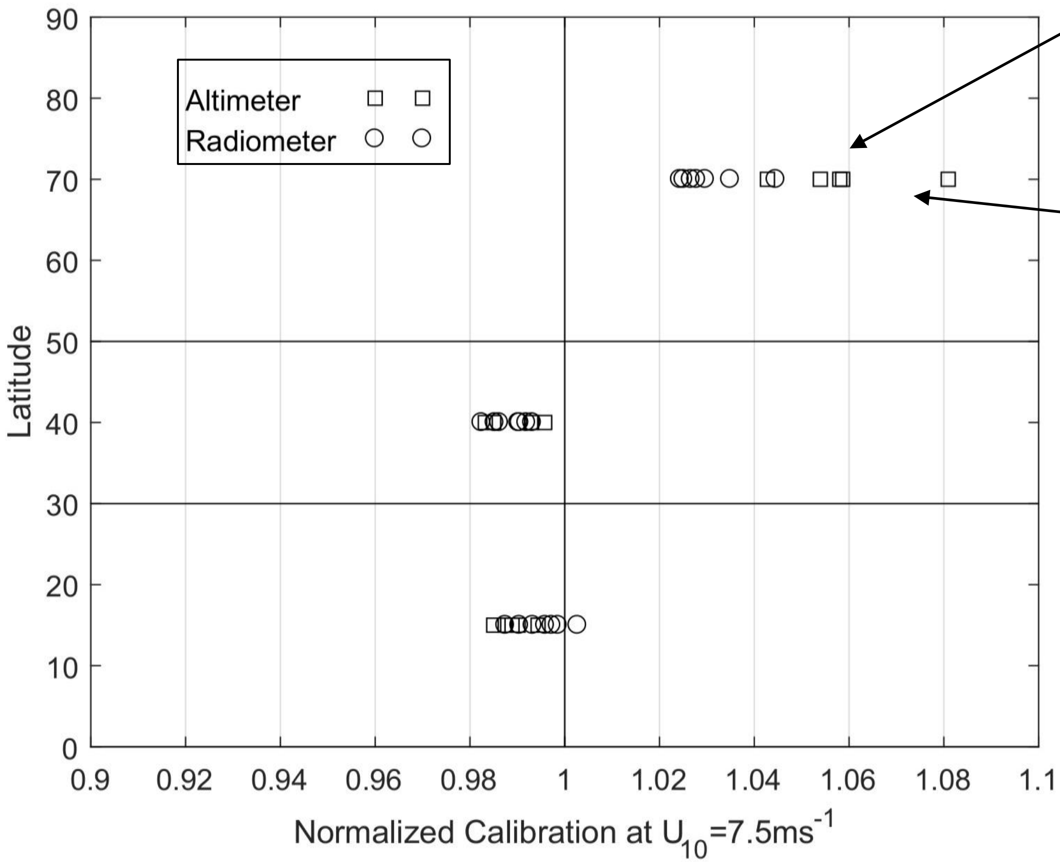
No offset in latitudes where both instruments calibrated

Altimeter higher than radiometer

Which is in error?
Altimeter or radiometer?

Regional calibration vs global at U_{10} =7.5 ms^{-1}

Buoy calibration segmented by latitude



Altimeter increase twice that of radiometer

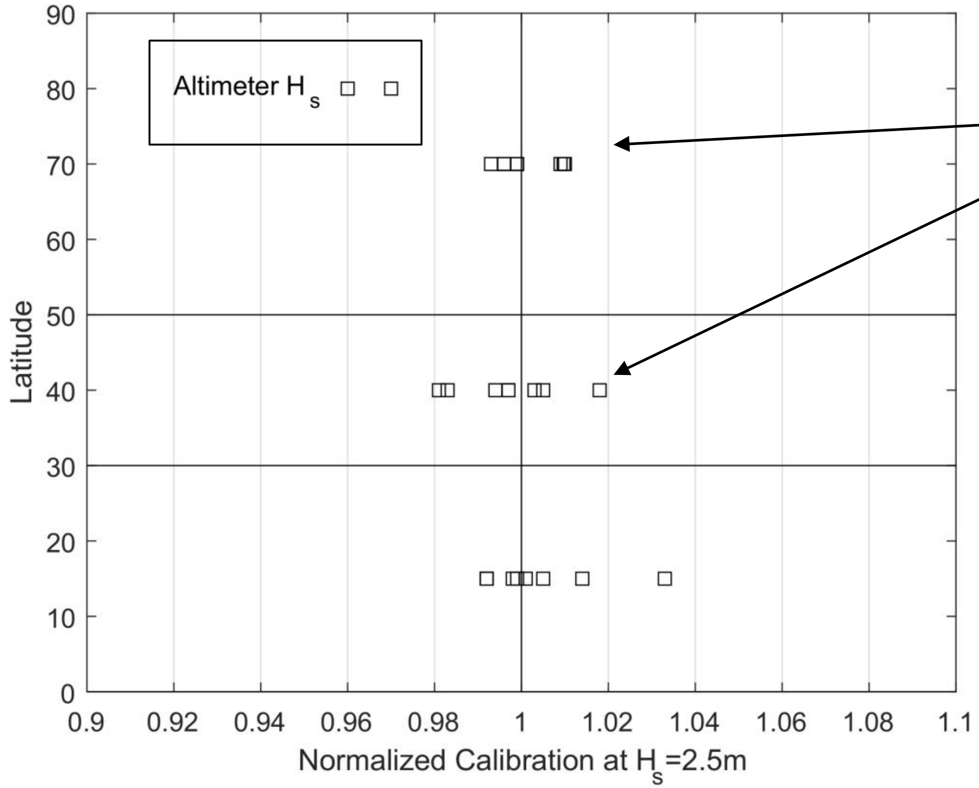
Both instruments yield higher values than buoys at high latitudes

Most of the buoys at these latitudes

Radiometer and altimeter similar

Regional calibration vs global at H_s = 2.5 m

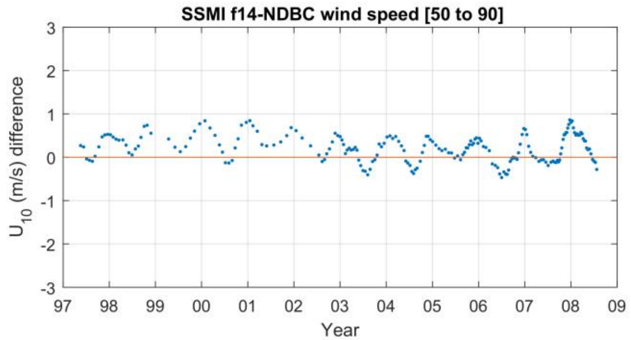
Buoy calibration segmented by latitude

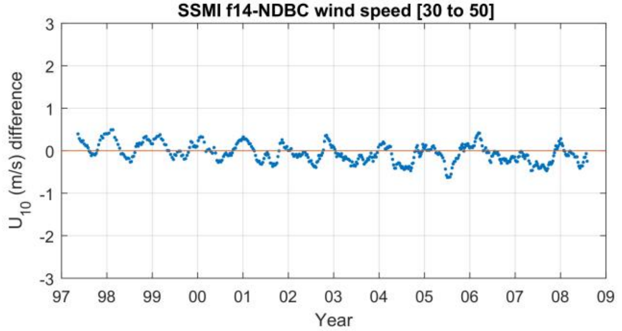


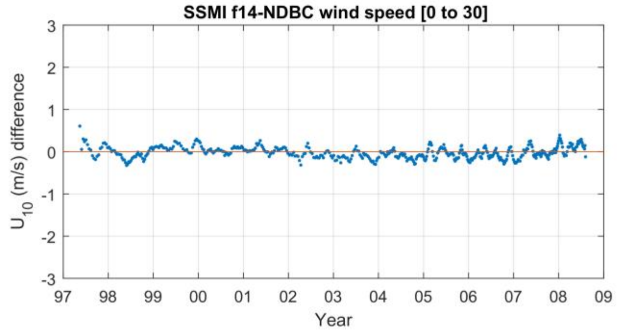
No bias as a function of latitude

Wind speed impacted but not wave height!

Radiometer – buoy differences by latitude



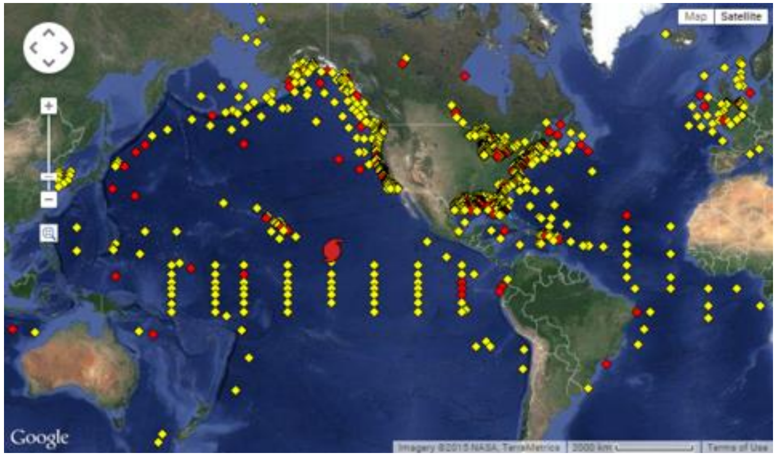




Magnitude of annual oscillations increases with latitude

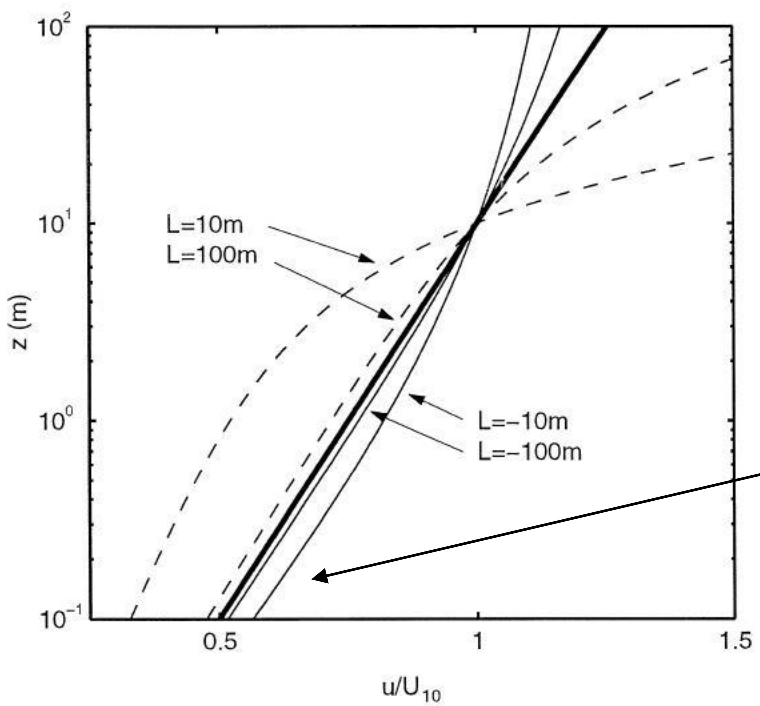
Difference from buoys increases with latitude

Consistent with previous observations



Stability impacts

I.R. Young / Coastal Engineering 34 (1998) 23–33



Satellites actually measure properties of high wavenumber components of the spectrum

- Radiometer – brightness temp
- Altimeter – radar cross-section

These properties related to near-surface wind speed.

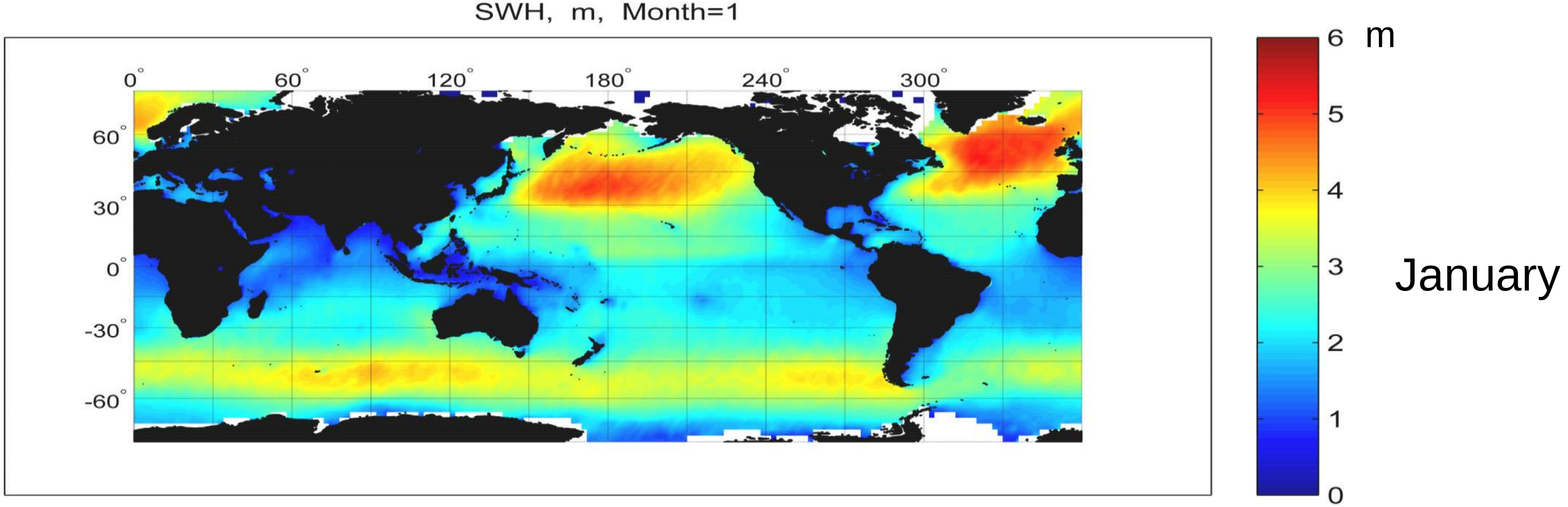
Calibration effectively relates near-surface wind speed to U_{10}

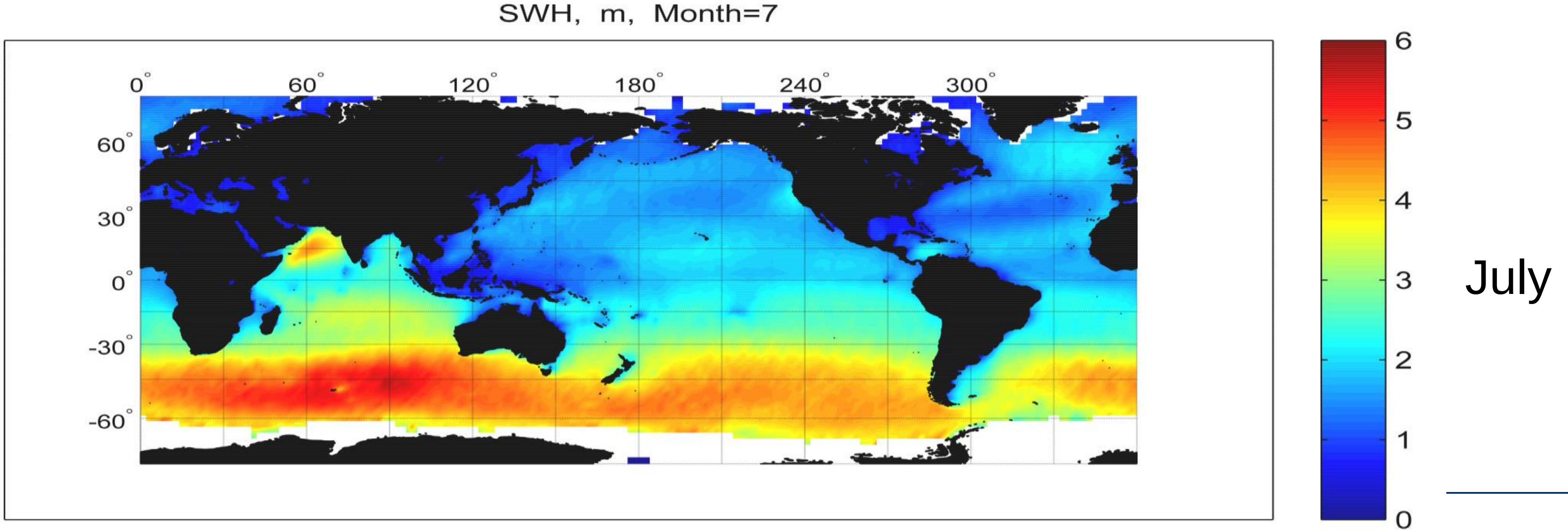
L – Obukhov scale height

-ve unstable (water warmer than air)

Overestimate in unstable conditions!

Global climatology – Hs Mean monthly - altimeter

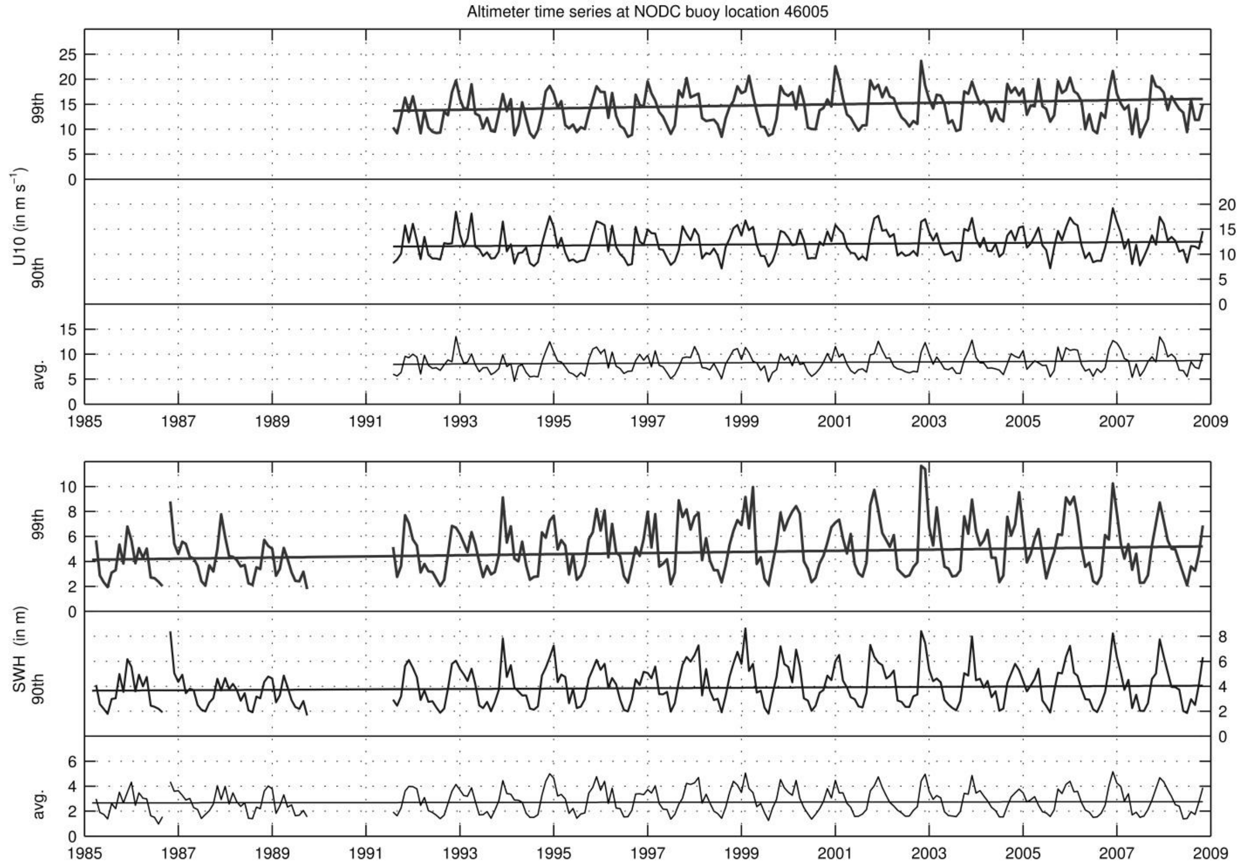




Global Trends

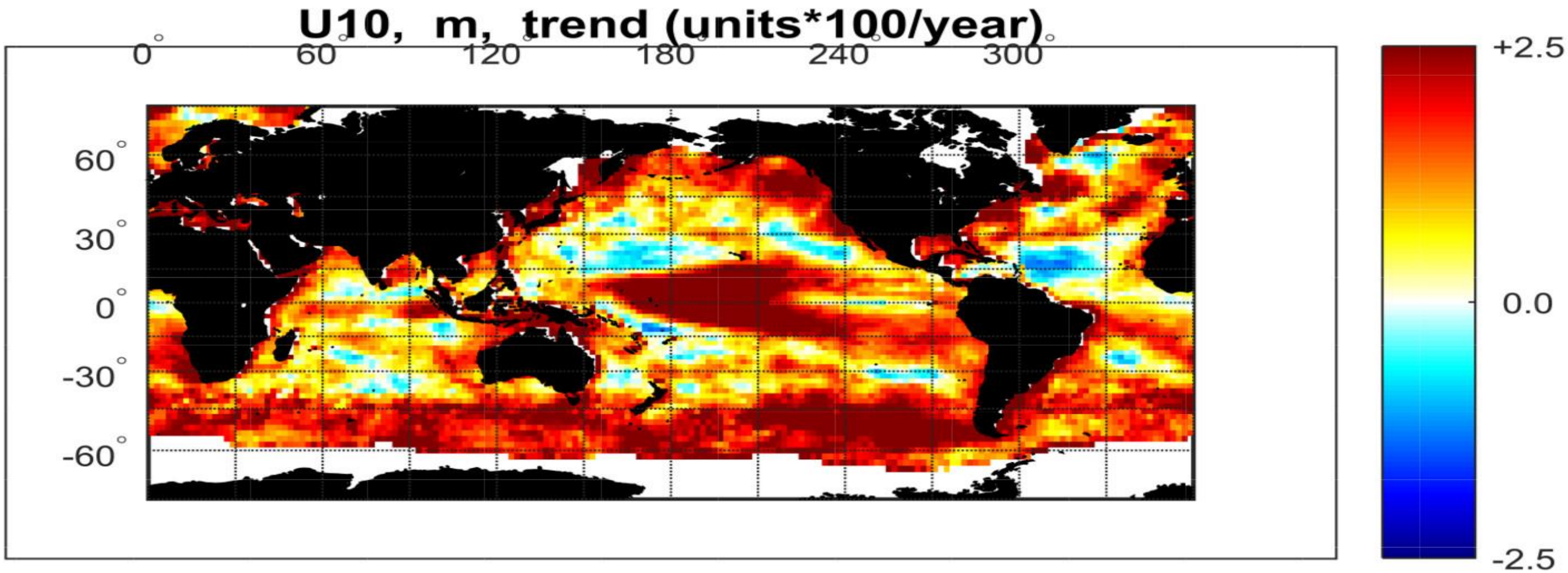
Aim is to determine long term trend in the presence of large seasonal signal

Use Seasonal Mann-Kendall test for Trend



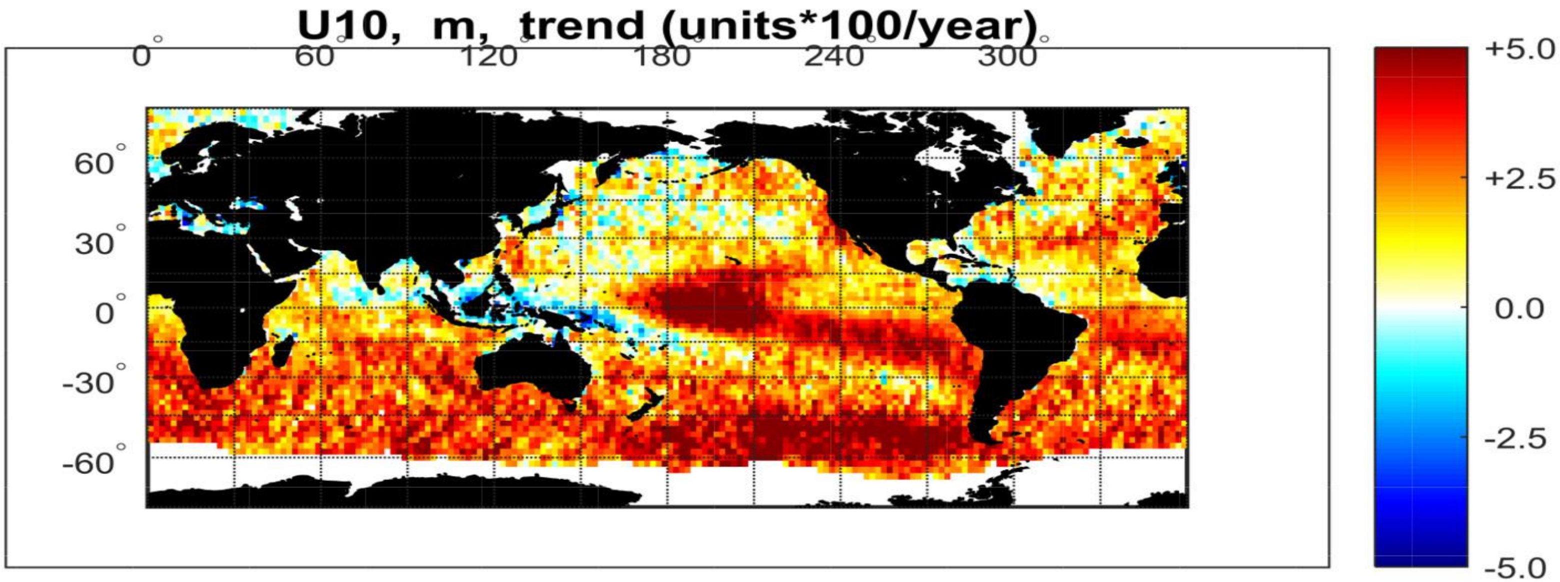
Young, Zieger and Babanin (2011), Science

Mean monthly U_{10} trends



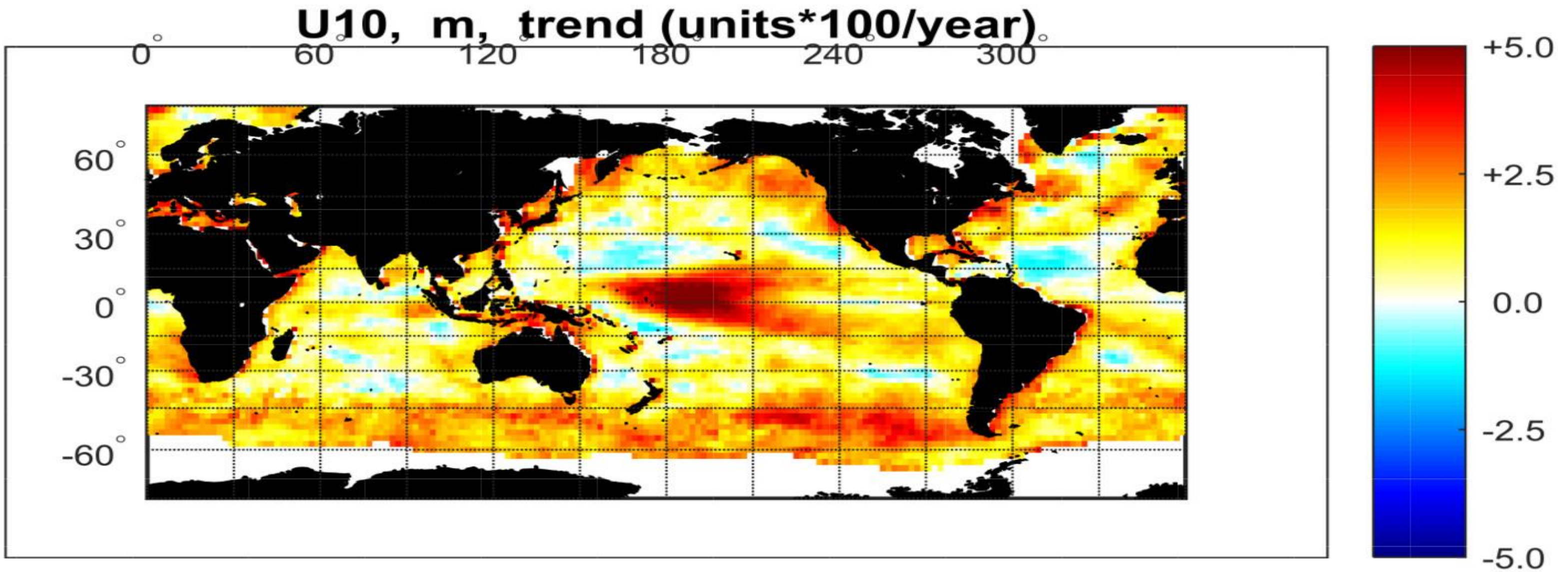
cm/s/yr

SSMI/
Scat



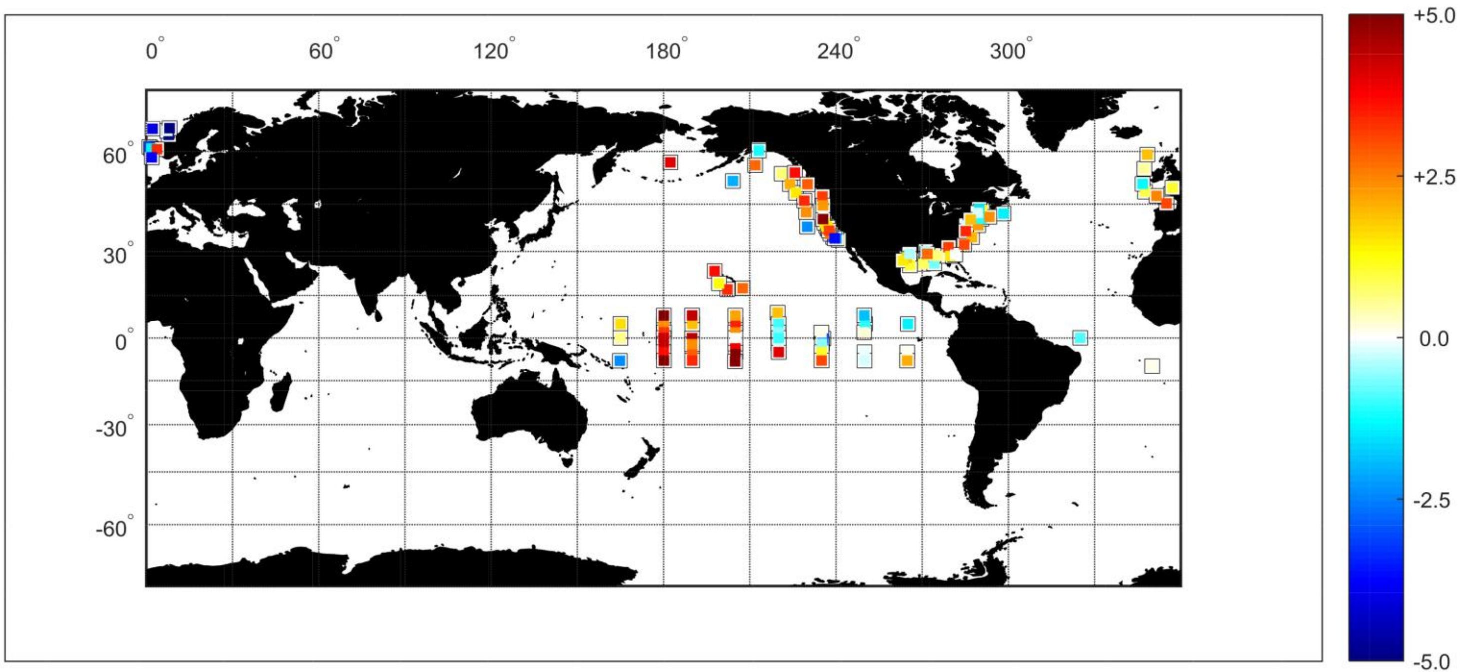
Altimeters

SSMI/Scat U_{10} trends compared to buoys



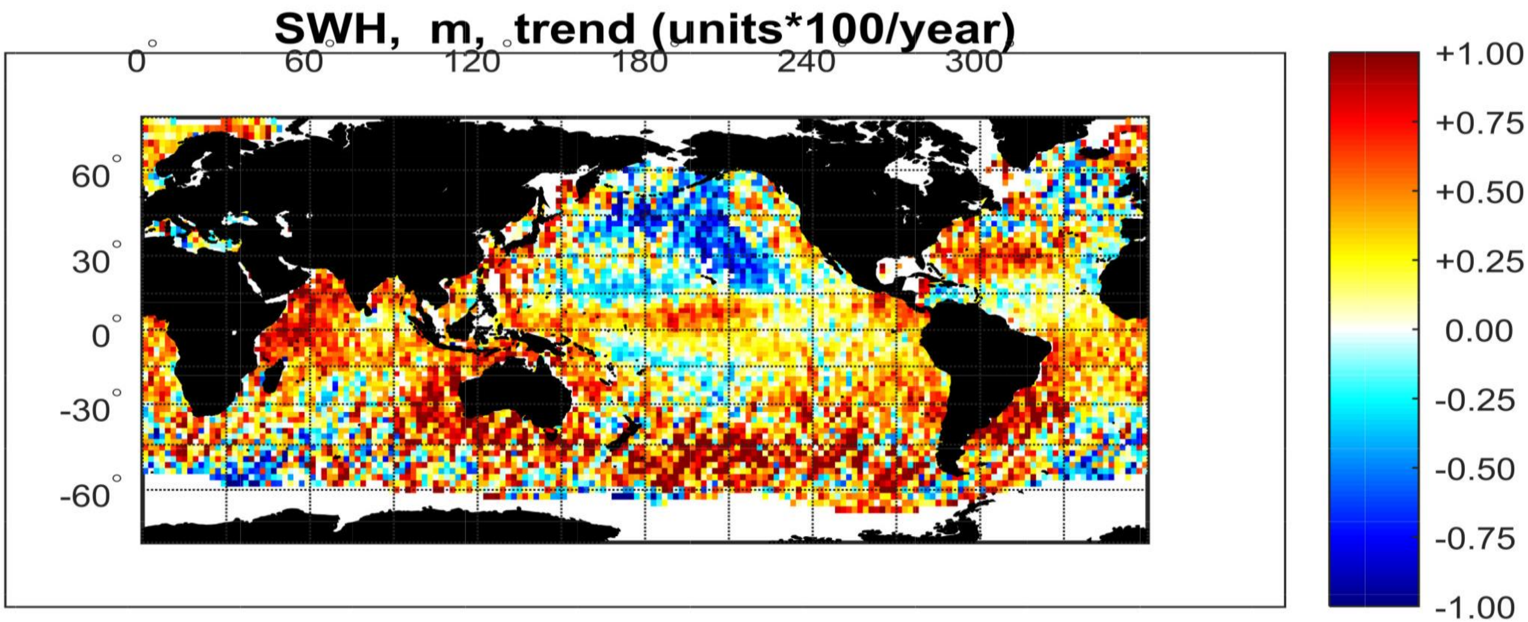
cm/s/yr

SSMI/
Scat



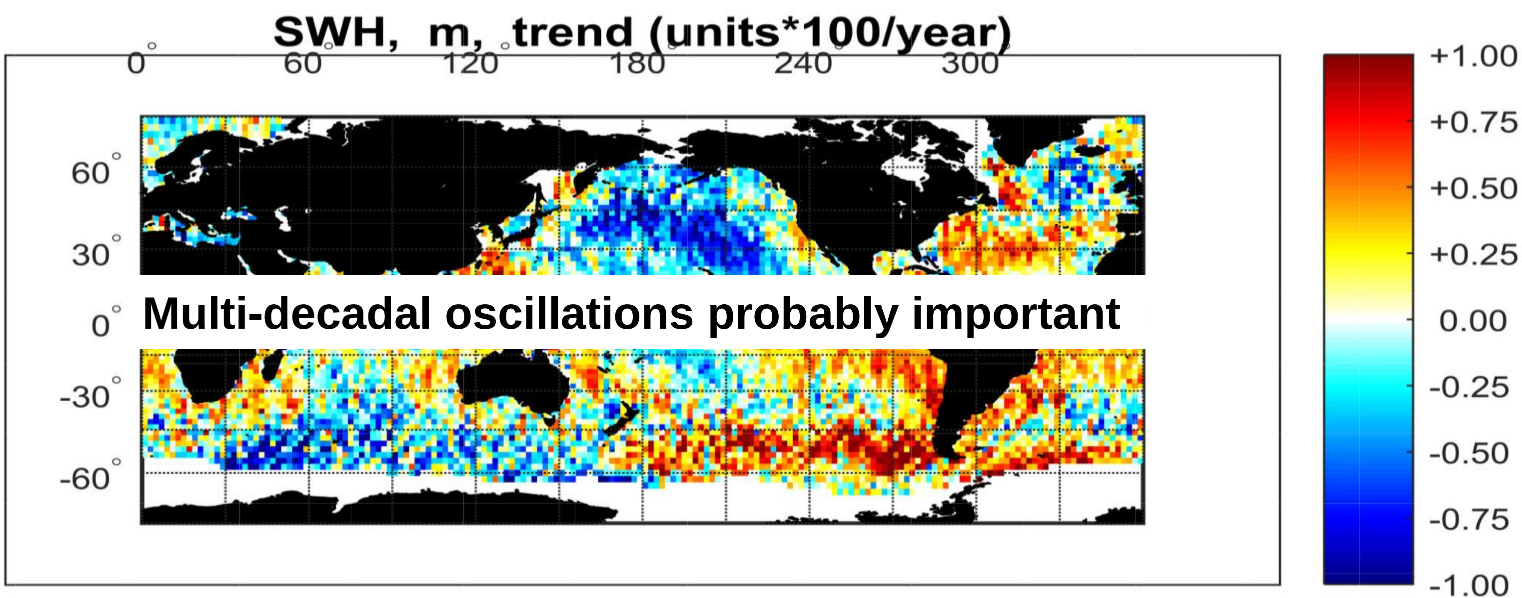
Buoys

Mean monthly H_s trends - altimeter



cm/yr

1985 - 2008

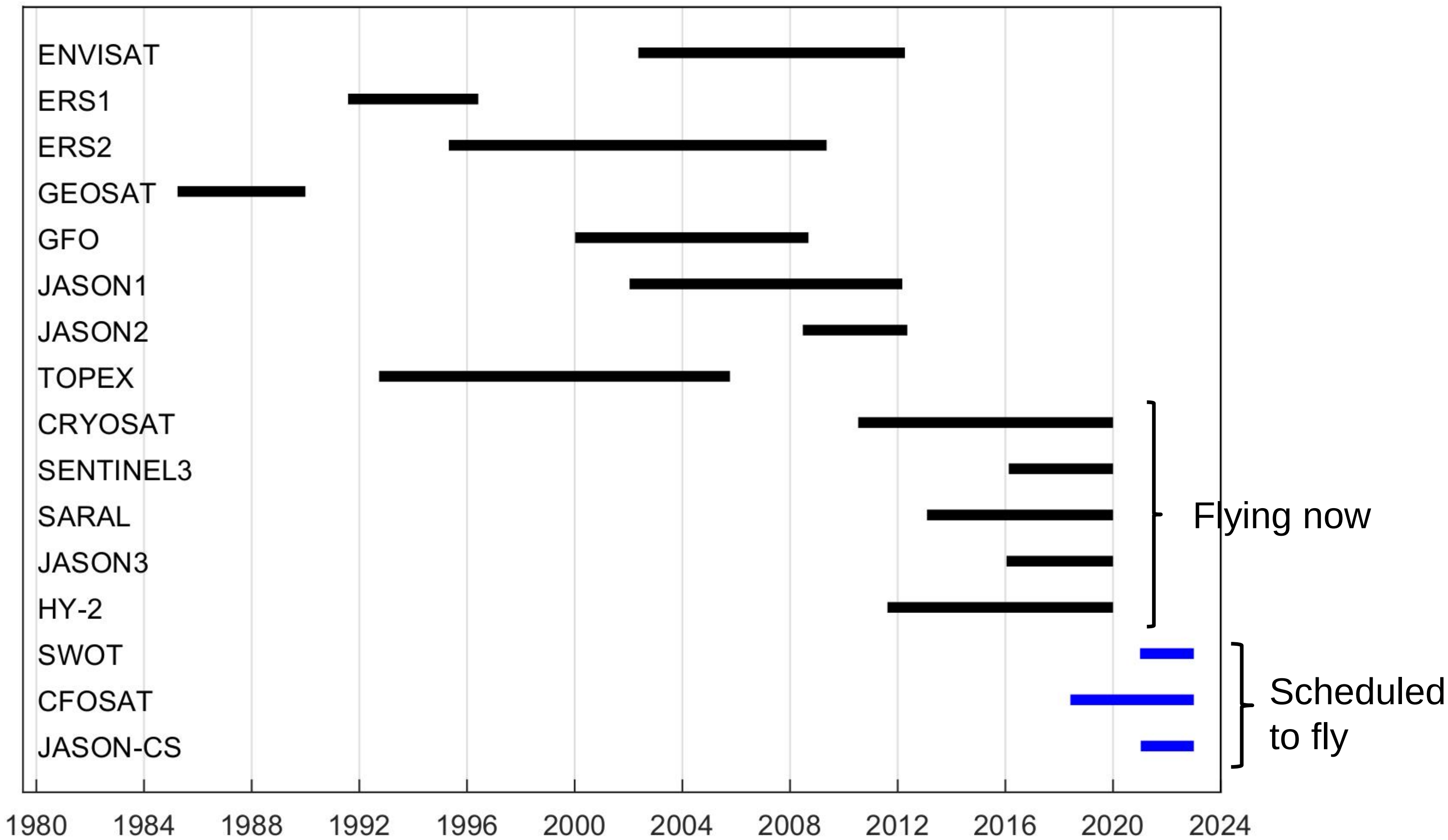


Multi-decadal oscillations probably important

cm/yr

1985 - 2013

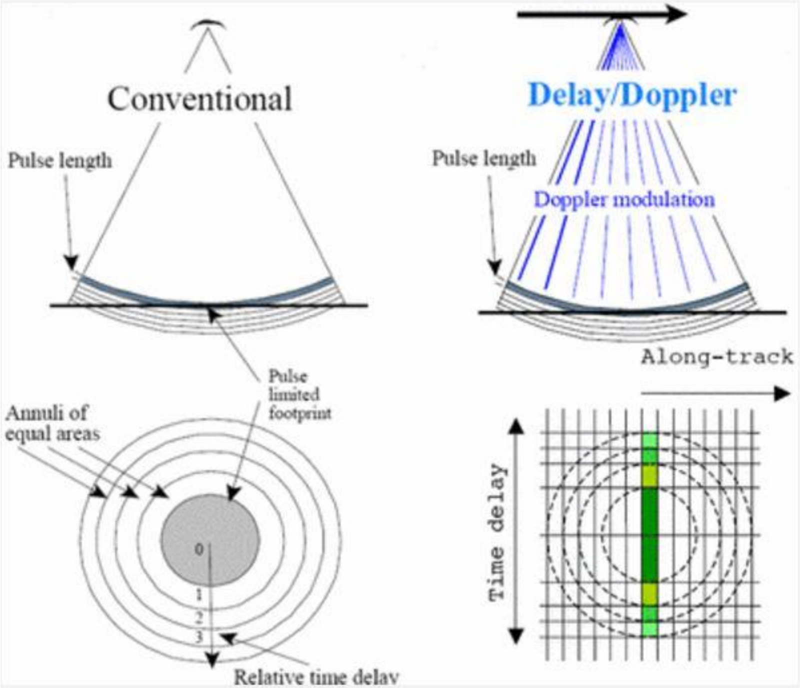
What does the future hold



High resolution altimeters

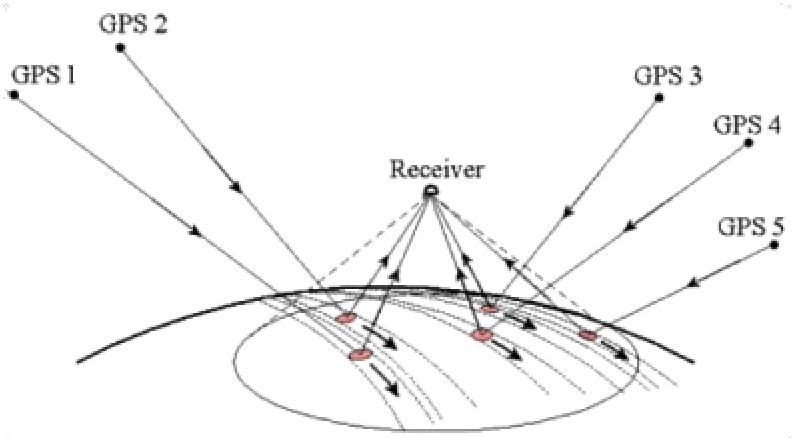
- **Higher frequency** – eg. SARAL Ka band brings footprint down to 3 to 5km

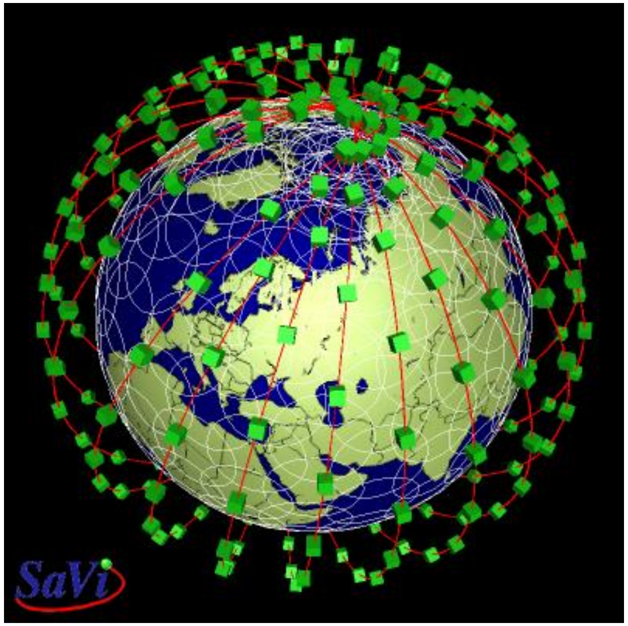
- **SAR mode altimeters** – eg. CRYOSAT, SWOT (250m along track resolution)



Arrays and Constellations

- Use GPS arrays – potentially vastly increase data available





- Constellations – low cost small systems
- Potential for continuous coverage

The Data Repository

- A single site where uses can obtain:
  - Data from all platforms
  - Calibrated and validated
  - Consistent format
  - Documented
  - Quality controlled

- We are close to having this, what is needed now are the resources to take it from an in house resource to a public resource

- Need to fund it long term

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