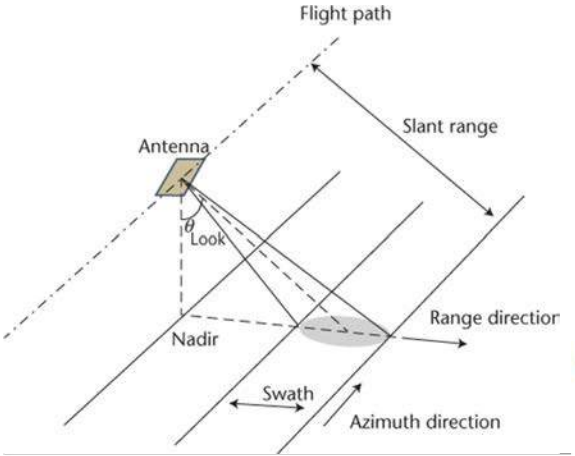
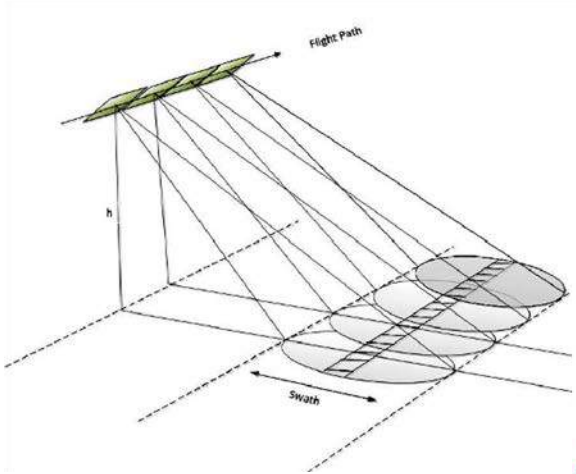
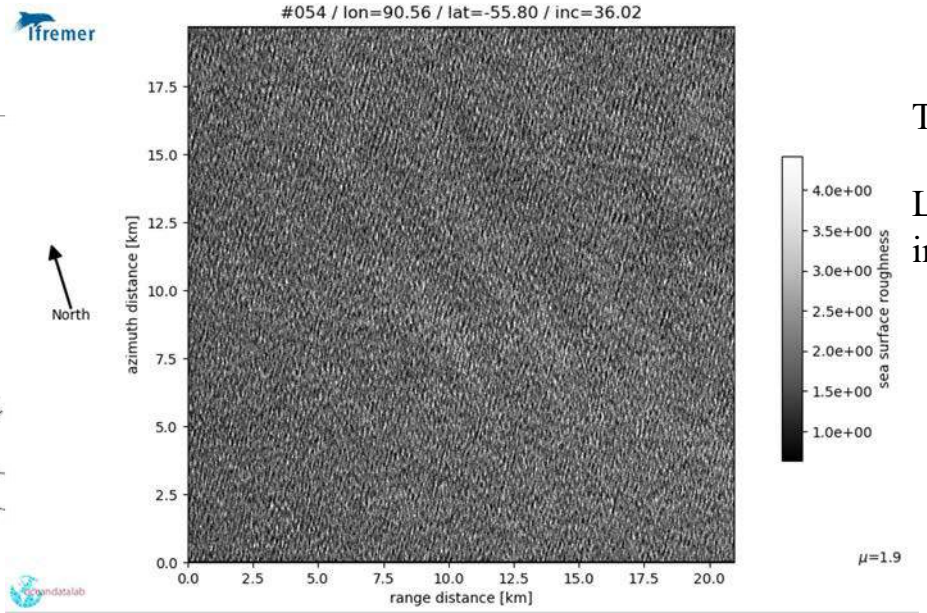
SAR Basics -1





- Active instrument, typically uses microwave bands - works in all atmospheric conditions & day/night, measures amplitude and phase
- Can achieve fine spatial resolution (<10 m) independent of platform height
- Resolution $\delta = (Z_{platform}\ \lambda_{EM}) / L_{antenna}$
  - δ=(850 km)(5 cm)/(10 m)=4.25 km
  - Simulates a large $L_{antenna}$ by superposition… larger $L_{antenna}$ → finer δ
- SAR works well or "easy to interpret" when the target does not move!



Typically ocean image

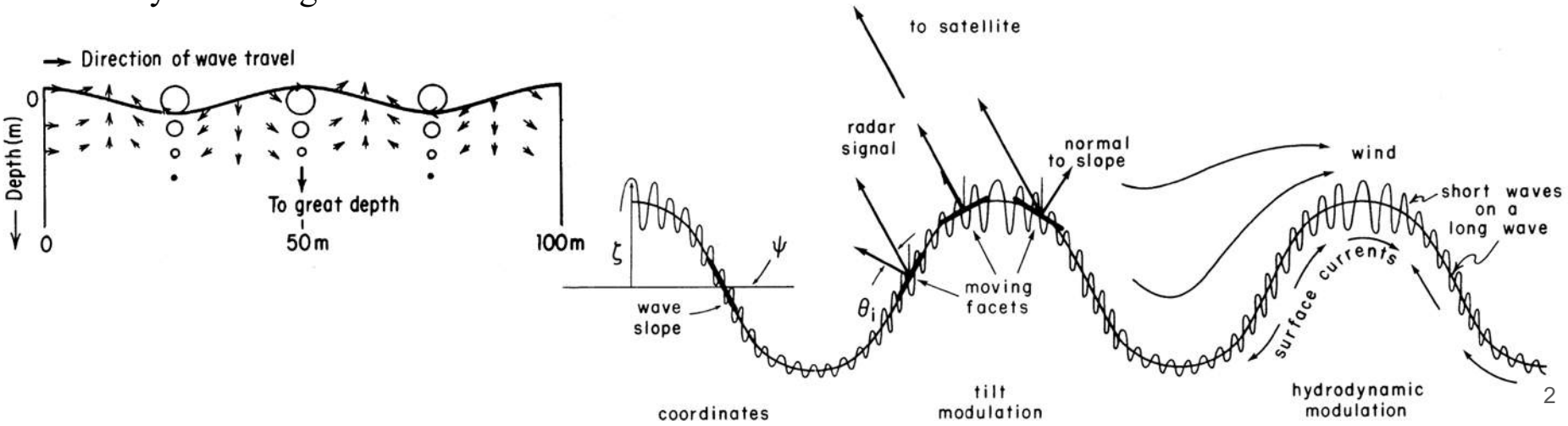
Looks blurry due to SAR imaging mechanisms

SAR Basics - 2

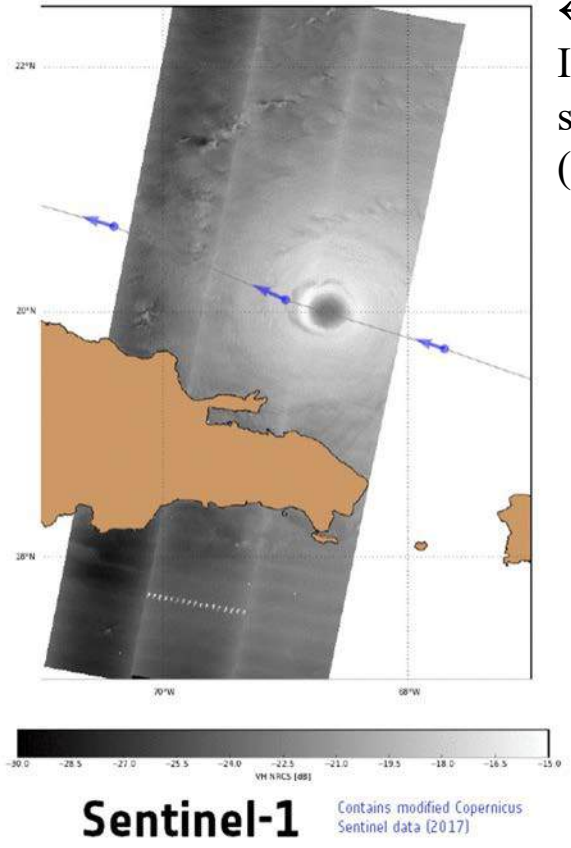
Ocean signals are difficult to interpret because of

- hydrodynamic modulation - ocean waves modulate the amplitude of the shorter waves, and thus the backscatter intensity (theories still lacking)
- tilt modulation - ocean waves modulate the local geometry and slopes of the sea surface (important for low incidence)
- velocity bunching* - the wave orbital velocities, with surface convergence and divergence, produce modulations in the image as the scatterers moving on the waves are placed according to these induced Doppler velocities (dominant)

Velocity Bunching



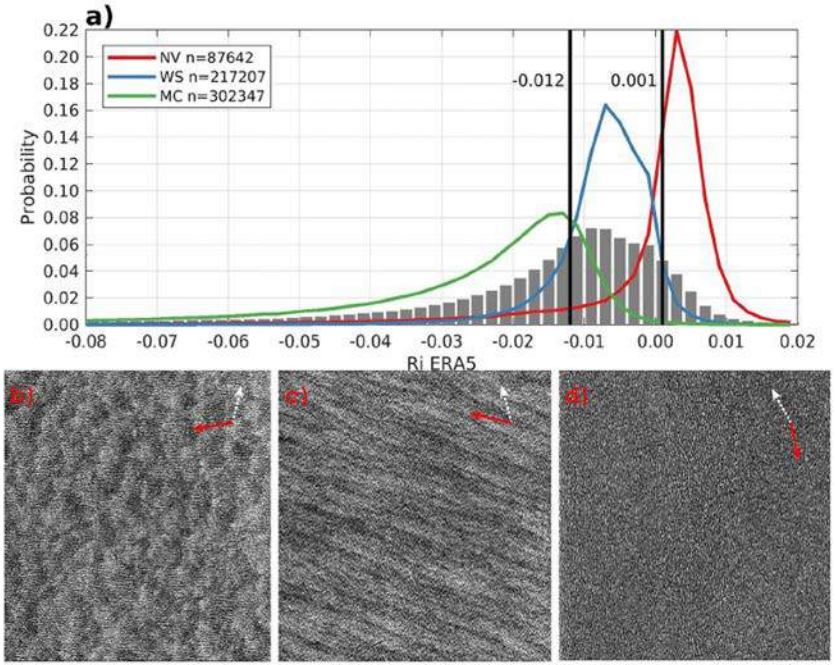
SAR Applications



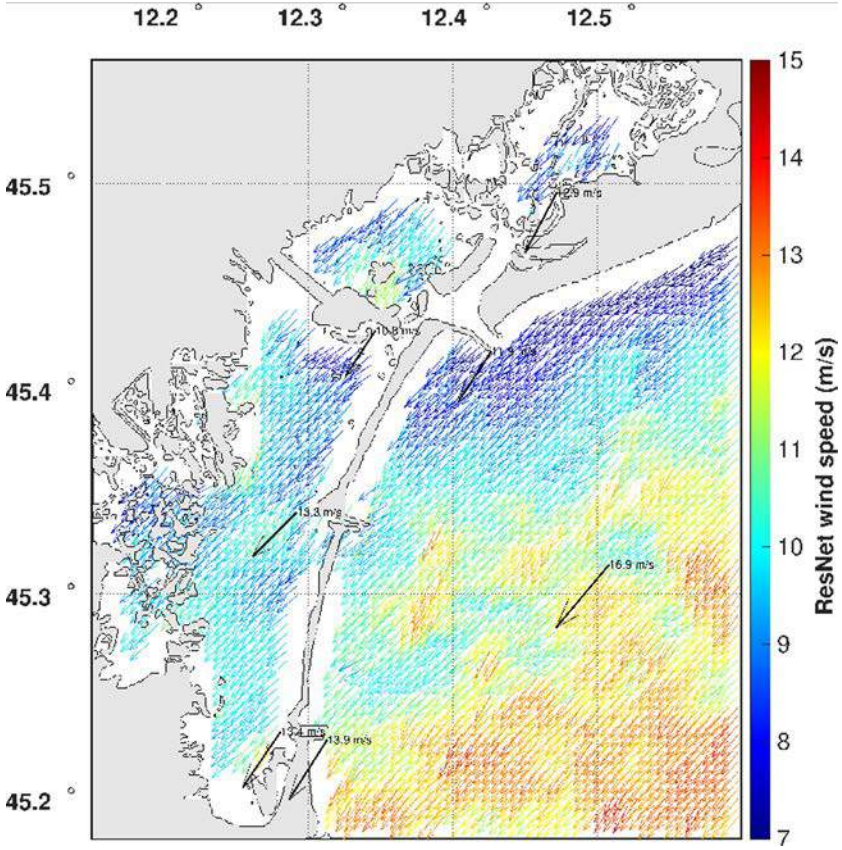
←SAR gets the extreme wind speeds accurate!
Irma 2017 - Cross-polarization (VH) does not saturate under extreme winds
(A. Mouche, IFREMER)

SAR textures map to atmospheric stratification
→cells ~unstable
→rolls ~near-neutral
→none ~stable

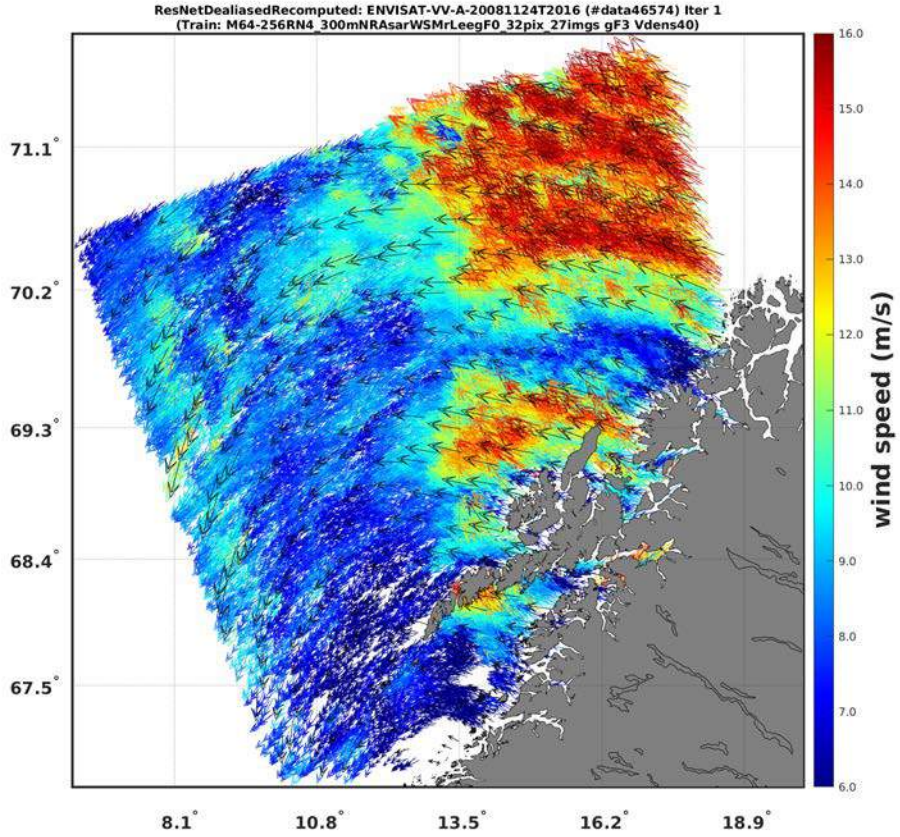
Stopa et al., GRL 2022⟶



Convolutional Neural Network (CNN) for wind retrieval. Case of Venice Lagoon



CNN winds (colored) for validation of coastal scatterometer winds (black)



SAR Availability

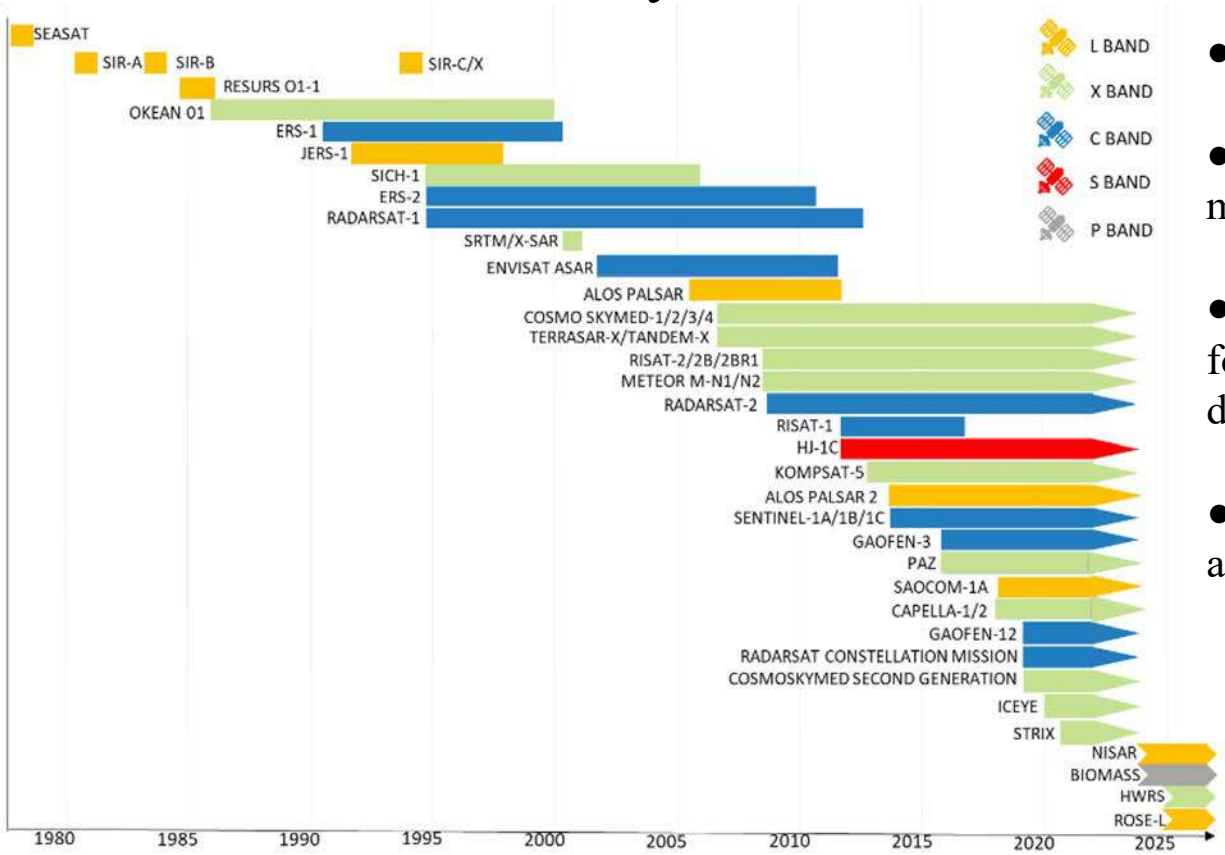


Image: Alfredo Fernández-Landa

- X, C, L, P ~ 3, 6, 24, 65 cm
- ESA has an open data policy making Sentinel-1 readily available
- NASA's NiSAR is in L-band - focus on cryosphere and land - open data
- There are private SAR companies allowing on-demand acquisitions