# ENVISAT Wave mode story and achievements

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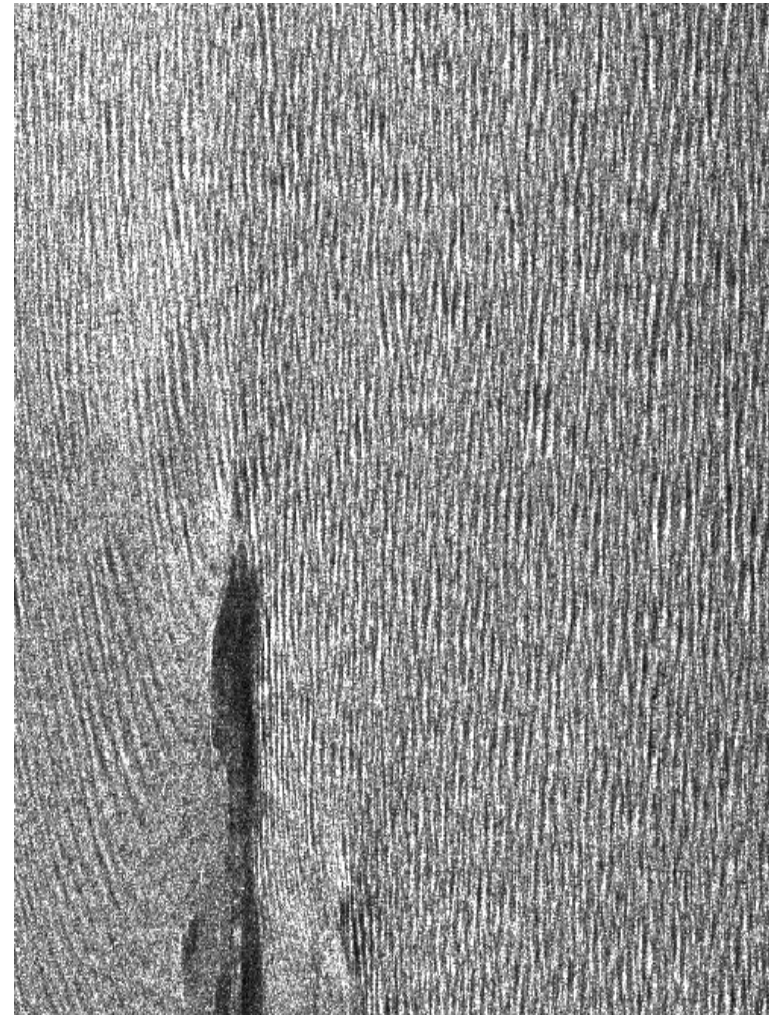
Envisat ASAR Wave Mode

Successor of ERS Wave Mode:

- Wave Mode concept operationally since 1991 (ERS-1, ERS-2).

- ASAR Wave Mode (2002->) – improved successor of ERS Wave Mode

Improvements:

- Better coverage of the World's oceans (8 times)
- Greater instrument flexibility (geometry, polarization, coverage)
- Improved processing, calibration, dynamics and products
- Introducing cross spectral technique in *Level 1b* product
- Introducing the *Level 2* product

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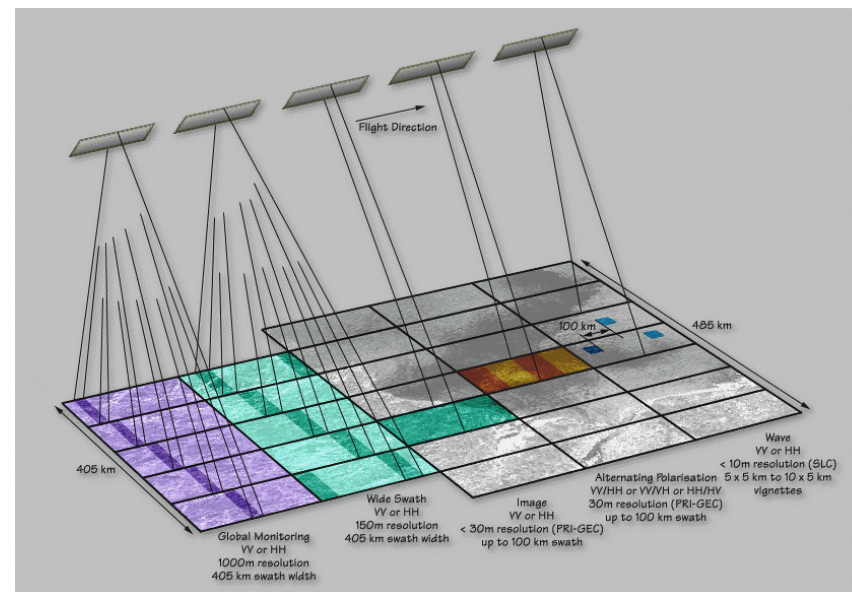
Historical highligths

Achievements with ERS-1, ERS-2:

- Development of the Ocean-to-SAR Spectral Transform *(Hasselmann et al, 1991 JGR), (Krogstad, 1992 JGR)*

- Different inversion schemes exist *(Hasselmann et al, 1996 JGR, Engen et al, 1994 TGARS, Krogstad et al, 1994 Atm.Ocean, Mastenbroek 1999 JGR)*

- Assimilation experiments performed *(Breivik et al, 1998 JGR),(Hasselmann et al, 1997 JGR)*

- Spectral wave climate applications *(Mastenbroek, CEOS SAR, 1998)*

- Development of the Ocean-to-SAR Cross Spectral Transform *(Engen et al, 1995 TGARS) (Vachon & Raney, 1991 TGARS)*

- Inversion of Cross-Spectra *(Engen et al, 1995 TGARS) (Dowd et al, 2001 TGARS)*

Achievements with ASAR:

- New Level 1b Product based on Cross-Spectra *(Johnsen H., et. al. 1998 Proc. CEOS SAR Workshop   )*

- New Level 2 Product based on direct inversion of the Cross-Spectra Spectral Transform (Quasi-Linear) *(Johnsen et. al., 1999 SRD),(Johnsen et al., SeaSAR 2006)*

- Inversion and Assimilation experiments using both Level 1b and Level 2 *(Schulz-Stellenfleth, J., et. al., JGR 2005, Aouf et al. 2008, Abdalla et al., SeaSAR 2010,)*

- Higher-order products and applications developed *(Collard et al., GRL, 2009, sopranos.cls.fr)*

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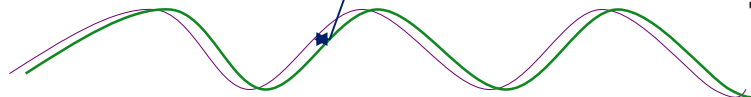# Cross Spectra Processing

ASAR WM Cross-Spectra

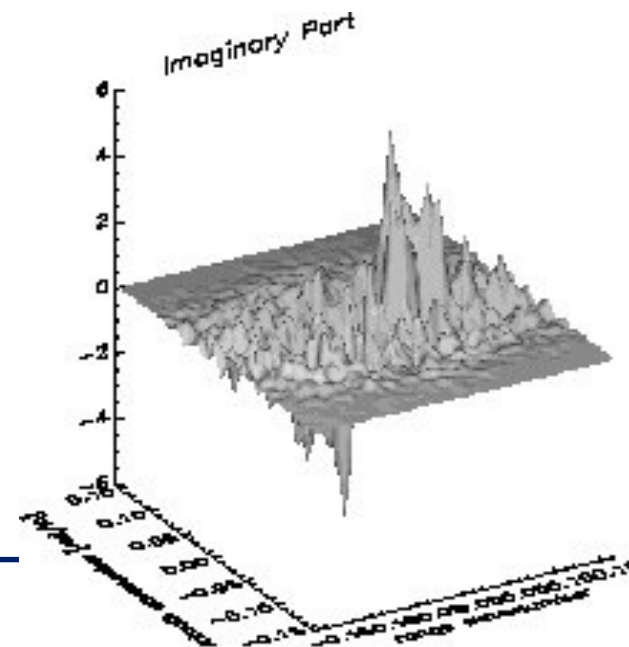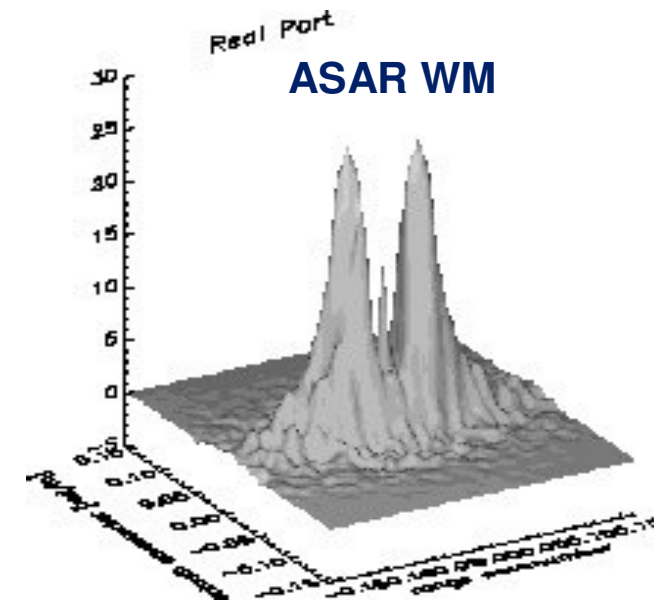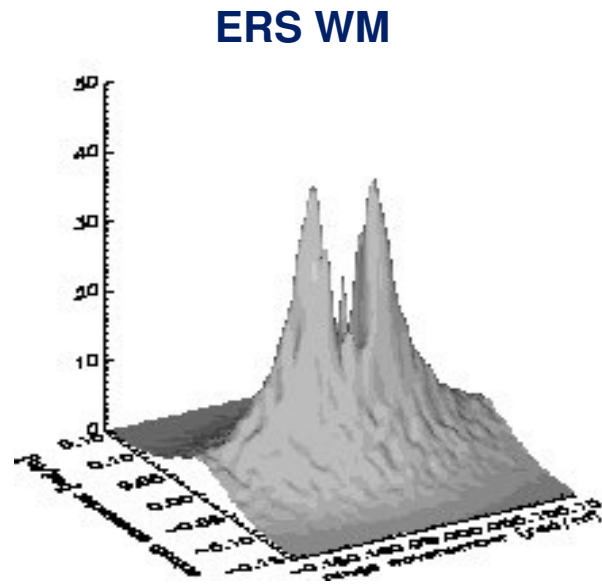Look 1

Look 2
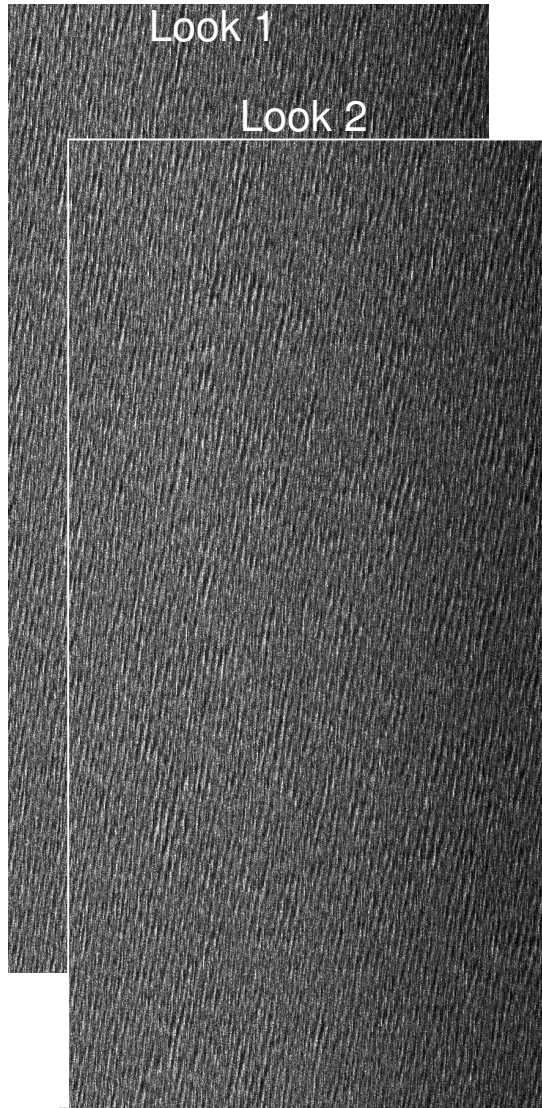
Spectral Estimation

$$P_{SAR}^{(m,n)}(\underline{k},\tau) = \frac{1}{\left\langle I^{(m)}\right\rangle\left\langle I^{(n)}\right\rangle}\left\langle I^{(m)}\left(\underline{k},\frac{\tau}{2}\right)I^{(n)^*}\left(\underline{k},-\frac{\tau}{2}\right)\right\rangle$$

$$\tau \approx 0.47\sec$$

$$\Delta\varphi = \omega_k\cdot\tau \approx 12^o$$

Cross Spectra — Re

azimuth wavenumber [rad/m]

range wavenumber [rad/m]

Cross Spectra — Im

azimuth wavenumber [rad/m]

range wavenumber [rad/m]

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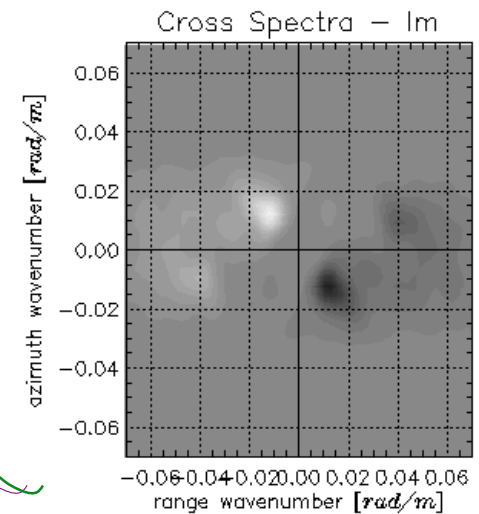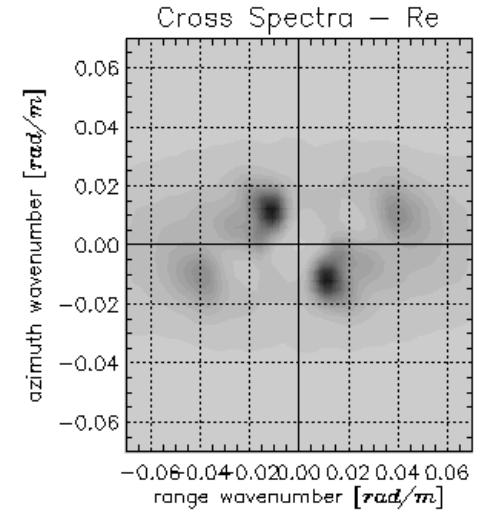
ERS WM versus ASAR WM Level 1b Product:

ERS WM

ASAR WM

Real Part

Imaginary Part

Main improvements:
-Wave Direction Ambiguity Removal
-Speckle Noise Bias Removal

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# Ocean Wave Spectra from Cross- Spectra
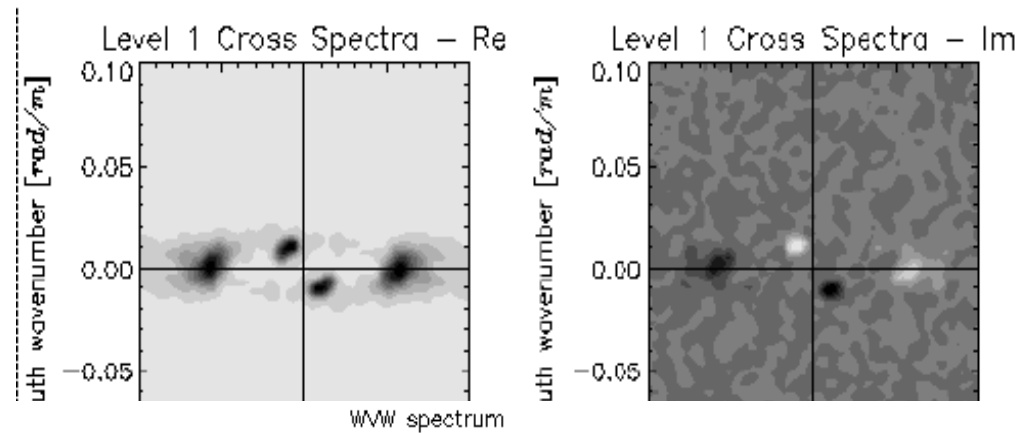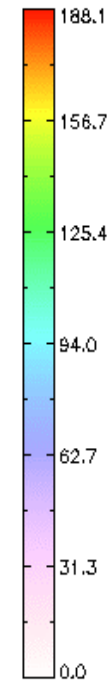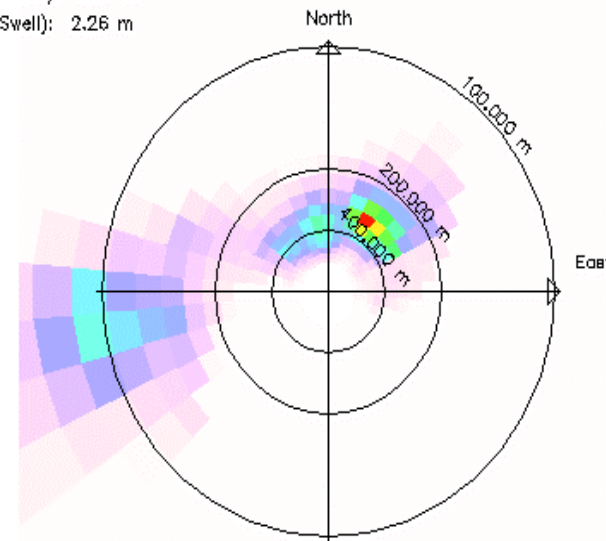
Evolution History of the ASAR WM Level 2 Product

- 2001: First version ready (only with test data)

- 2005: Major upgrade of algorithm using real data
  - Quality flagging improved
  - Improved wave direction ambiguity removal
  - Improved removal of non-wave signature
  - Improved cut-off estimation
  - Transfer function modifications
  - Extension to HH polarization and S4
  - Additive noise correction

- 2010: Minor upgrade
  - Upgrade of look-up tables for improved RAR MTF

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Sentinel-1 OCN Product

- Level 2 Ocean Product (OCN):
  - Ocean surface wind field (OWI)

    +
  - Ocean swell wave field (OSW)

    +
  - Ocean surface radial velocity field (RVL)

- One single file contains all three components (on separate grids)
- netCDF file format
- Developed by: Norut (Norway) & CLS (France)

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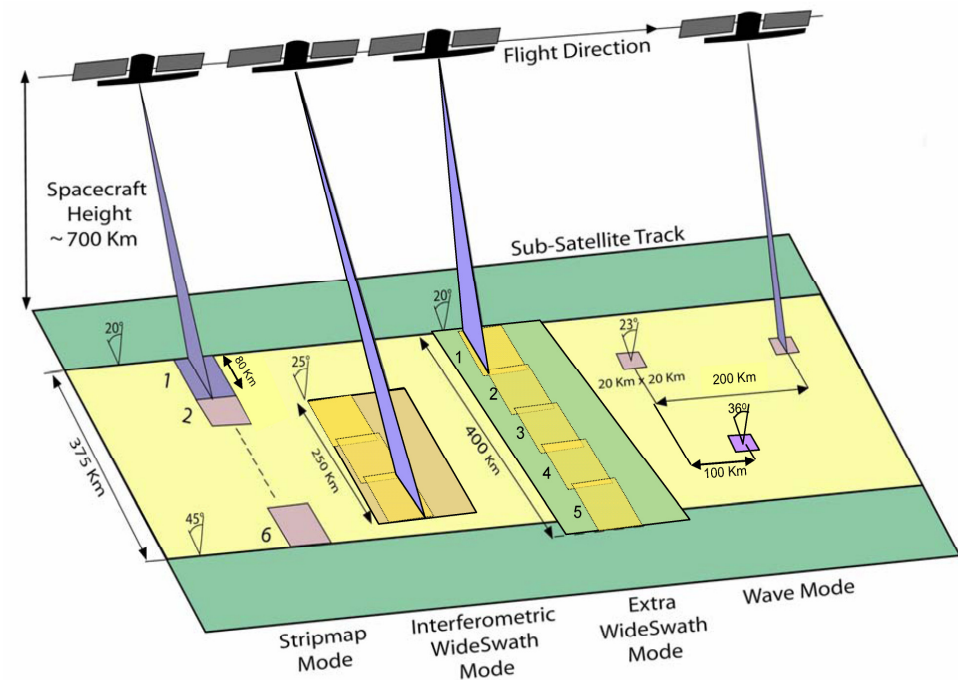
R&D Recommendations

- <u>Sentinel-1 Wave Mode</u>
  - The high range bandwidth should be exploited to derive wind sea and wind vector informations as part of the Level 2 processing.
  - The unique capability of global and simultaneous measurements of surface wind, wave and radial velocity should be exploited to achieve better and consistent model descriptions (MTF, NRCS, Doppler)

- <u>Sentinel-1 TOPS Modes</u>
  - Pre-launch TOPS data should be acquired to help developing the TOPS ocean product
  - Wave spectra processing should be implemented to align with WM and SM modes processing